Synergies and trade-offs between sanitation and the sustainable development goals

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Abstract
To better leverage opportunities arising out of sustainable and inclusive management of sanitation services there is a need for robust and comprehensive evidence of the wide-ranging benefits that sanitation can deliver. The Sustainable Development Goals (SDGs) provide a comprehensive framework for sustainable development broken down into 169 interconnected Targets which are articulated under 17 Goals. Based on a methodology developed at University College London (UCL), this study identifies linkages between sanitation and the 169 Targets corroborated by published evidence. We show that there are synergies between sanitation and all 17 Goals and 130 (77%) of the Targets, and trade-offs for 28 (17%) of the Targets. We identified 83 Targets (49%) that call for action in the sanitation sector. The results demonstrate the far-reaching benefits that can be unlocked from investment in sanitation, which extend beyond health and spread across sectors. The evidence base for the 17 Goals establishes links that can inform cross-sectoral action, collaborations and investment across governance levels for integrated sanitation solutions. The research provides different stakeholders with a framework that can be applied to context-specific cases and projects. We propose a range of recommendations to policy makers, practitioners and researchers who seek to take this study further to help achieve the SDGs.

Keywords: SDG, sanitation, interdisciplinary, cross-sectoral partnerships, synergies, trade-offs, sustainable development, water, the environment
Introduction

In September 2015, the United Nations (UN) adopted the 2030 Agenda for Sustainable Development. Comprising 17 Sustainable Development Goals (SDGs) and 169 Targets, the Agenda proposes a comprehensive global plan of action for ‘people, planet and prosperity’. SDG6 aims to ‘ensure availability and sustainable management of water and sanitation for all’ by 2030 [1], p. 18. It builds on the largely unmet water and sanitation target of the Millennium Development Goals (MDGs) on environmental sustainability; MDG targets failed to support a systemic approach towards sanitation that considered the sanitation chain in its entirety. In 2017, 55% of the world’s population still lacked access to safely managed sanitation, including an estimated two billion who did not have basic access [2]. The severe implications of poor sanitation on morbidity rates, health care costs and productivity losses and inadequate sanitation is estimated to cost the global economy USD 260 billion per year [3]. Our research calls for particular attention to the sanitation dimension of SDG6 and demonstrates that major gains are possible for all goals if universal access to adequate and equitable sanitation is to be achieved.

We argue that the SDGs provide a framework to identify priority areas of investment to maximise impact. An increasing number of studies have adopted such an approach and identified priorities for integrated policies from the analysis of relationships between all SDGs (see e.g. [4–7]). At the sectoral level, assessments have been carried out for links between the SDGs and marine ecology and management [7], energy systems [8–10], climate action [11] and ecosystems [12]. In addition, recent studies have explored linkages between the SDGs and infrastructure systems [13], the SDGs and water [14–16], as well as the water–food–energy nexus among the SDGs [17]. Yet, linkages between sanitation and the SDGs and their potential contributions to public health, the economy and the environment remain under-studied and require evidence-building for practical action.

The Sustainable Sanitation Alliance (SuSanA), an informal network of 11,000 individual members and 353 partner organisations working towards sustainable sanitation solutions, explored the linkages between sanitation and SDGs in order to maximise opportunities to improve access to sanitation [18]. The network highlighted the relevance of sustainable sanitation to meeting the 2030 Agenda by presenting links between sustainable sanitation and all the SDGs and sought to encourage sanitation sector professionals to take action and strive for intersectoral cooperation [18]. Building on the work of SuSanA, this study adds value by presenting a novel and replicable evidence-based methodology that enables a systematic exploration of linkages, disaggregated by actions, synergies and trade-offs, between sanitation systems and the 169 Targets. Revealing these linkages not only highlights the importance of sanitation to other SDGs but can further provide valuable insights into the potential and scope for synergistic efforts towards the 2030 Agenda. The expandable evidence base provided offers a starting point to enhance existing knowledge and demonstrates the value of incorporating sanitation into innovative and integrated approaches and investments.

The aims of this study are twofold: 1) to provide a replicable methodology that establishes linkages with the comprehensive 2030 Agenda and that can be applied in specific contexts to demonstrate the wide-ranging benefits of sanitation that extend across sectors and beyond health; 2) to establish an evidence base of published material to be further expanded as part of efforts to strategically meet the SDGs. Overall, this paper argues that sanitation plays a crucial role in the achievement of the 2030 Agenda and will be key to developing policies and programmes that support sustainable development.

Methods

A research team from diverse disciplines spanning engineering, urban design and planning, health, social science, political economy, policy and law, worked together from the outset to develop an interdisciplinary approach for knowledge co-production. This approach enables the analysis of complex, interconnected global challenges, providing evidence to support the development of integrated interventions that transcend disciplinary boundaries to develop appropriate approaches and solutions.

The research presented in this paper is based on a definition of safe, inclusive and sustainable sanitation presented in Box 1 which builds upon two concepts. First, SDG Target 6.2, which by 2030 aims to ‘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 situation’. Second, the sanitation service delivery ladder established by the Joint Monitoring
Box 1. Working definition used for sanitation to ‘achieve adequate and equitable sanitation and hygiene for all’.

**Achieve access to adequate, equitable and dignified sanitation and hygiene for all, paying attention to:**
- Safely managed facilities and services for handling and disposal of human urine and faeces along the sanitation chain
- Social diversity and inclusivity (including gender, age, disability, religion)
- Capacity-building of local communities
- Menstrual hygiene and baby wash
- Ending open defecation

Programme (JMP), which emphasises ‘safely-managed’ sanitation and considers the entire sanitation chain (i.e. capture, containment, emptying, transport, treatment and re-use/disposal) (see also [19–21]) to ensure zero detriment to the environment.

Based on a review of existing definitions and discussions, the team noted the need to pay particular attention to the diverse needs of sanitation users, including disadvantaged and vulnerable groups (e.g. persons with disabilities), and the importance of menstrual hygiene and baby wash in the provision of sanitation services, which tend to receive less attention [22–24]. In resource-challenged settings, capacity-building of local communities is essential in the provision of sustainable and inclusive sanitation solutions that require an understanding of contextual socio-cultural factors [25]. This study is based on the assumption that only safely managed sustainable sanitation systems are implemented in order to capture the far-reaching benefits that sanitation can deliver and set standards for future infrastructure projects and associated policies.

In this study, the team adapted the in-house methodology developed at University College London (UCL) [9] for the sanitation sector. Using this structured process, the authors reviewed published evidence to identify linkages between sanitation, as defined above (Box 1), and all the targets of the 2030 agenda. The methodology followed a three step-process for each target, which involved the following questions (see Fig. 1 and Box 2):

A. Does the Target call for action in relation to sanitation, i.e. is an action required in the sanitation sector?

B. Is there published evidence of synergies between the pursuit of the Target and achieving access to adequate, equitable and dignified sanitation and hygiene for all?

C. Is there published evidence of trade-offs between the pursuit of the Target and achieving access to adequate, equitable and dignified sanitation and hygiene for all?
Using a structured process, the identification of linkages, i.e. call for action, synergies and trade-offs, was initially carried out through a blended approach whereby interdisciplinary pairs used their expertise and knowledge complemented by targeted literature searches to create an interdisciplinary evidence base. Following the method of Fuso Nerini et al. [9], the authors considered at least one piece of published evidence per target as verification of a synergy or a trade-off. The aim was to test the structured process and the application and replicability of the methodology to demonstrate the importance of sanitation in achieving the 2030 Agenda. In Step A, the authors explored and identified a linkage between sanitation and a target to assess how improvements in sanitation would affect the target in question. For Steps B and C, the team looked at reciprocal synergies and trade-offs between sanitation and all SDG targets. In all three steps, the published evidence considered was limited to academic studies and grey literature (e.g. UN reports) published in English. Sources used spanned urban planning, engineering, environment, health, social sciences and policy. The mapping identified existing evidence to indicate the types of synergies and trade-offs that have occurred in different contexts. Box 2 provides an illustrative example of how the methodology was applied for SDG 11.1.

In total, the team scanned over 500 publications. The results are presented in Appendix 1, which references 233 publications to support the identified calls for action, synergies and trade-offs for all 169 targets. Each Target provides a short explanation of the identified linkages for questions A, B and C. The preliminary results were compiled in the tabulated worksheet (Appendix 1) and scrutinised and validated by all authors, cross-checked in the same pairs, and presented in a workshop with participation from development practitioners engaged in policy, academia and the delivery of sanitation globally. The tabulated worksheet was then finalised jointly by the authors based on feedback during the workshop. The team was unable to identify published evidence for one Target (15.8 alien species) with potential links with sanitation and was therefore not shown as having a synergistic relationship with sanitation (Appendix 1).

To present the results of our study, all linkages identified have been clustered into four groups referred to as ‘domains’, which were drawn from the frameworks set by Fuso Nerini et al. [9] and Waage et al. [29]. The first group relates to Goals that seek outcomes of ‘individual and collective aspirations of greater welfare and wellbeing’ (SDG1, SDG3, SDG4, SDG5, SDG10, SDG16). The second group, ‘infrastructure services and innovation’, concerns the development of systems of production, distribution and delivery of goods and services (SDG2, SDG6, SDG7, SDG8, SDG9, SDG11, SDG12). The third group refers to ‘the environment and natural resources’ (SDG13, SDG14, SDG15). As in Waage et al. [29], we categorise SDG17 on governance and partnerships separately and thereby frame it as a distinct domain that provides institutional mechanisms which are a prerequisite for the delivery of the targets in groups 1, 2 and 3. As in Fuso Nerini et al. [9], the identification of linkages at Target level (in contrast to Waage et al. [29] who established them at Goal level) showed that similar linkages could exist between sanitation and more than one Target across different Goals.

Results

Our study identified linkages between sanitation and all 17 SDGs highlighting that action on sanitation supports delivery of the 2030 Agenda. Implementation of sustainable sanitation
systems would contribute significantly to the achievement of all 17 Goals at multiple levels – individual, household, community, society and environment. As shown in Fig. 2, the assessment found 83 (49%) Targets that required action to be taken concerning sanitation systems. Evidence of synergies and trade-offs were identified for 130 (77%) and 28 (17%) Targets, respectively. The higher number of synergies as compared to trade-offs highlights the wide-ranging benefits of sanitation that can further be explained through our working definition of sustainable and inclusive sanitation, which assumes dignity for all, safe management along the service chain and zero harm to the environment. These are discussed below with reference to a few selected sources of published evidence with the complete results of the assessment reported in Appendix 1 and summarised in Fig. 2. The linkages identified are presented below according to the four domains.

**Individual and collective aspirations of greater welfare and wellbeing**

Nine of the 13 Targets of SDG3 (‘Good health and wellbeing’) call for action on sanitation systems. Among all linkages identified, we highlight that sanitation interventions are required to help reduce pathogen transmissions to eliminate maternal and neonatal mortality (Targets 3.1–2); mitigate stress for pregnant women vulnerable to premature deliveries (Target 3.4); and improve hygiene in health
Synergies and trade-offs between sanitation and the SDGs

While our study revealed multiple linkages between sanitation and SDG5 (‘Gender Equality’), in practice, gender-inclusive sanitation has yet to be achieved at scale. Action in sanitation is particularly urgent where women and girls bear the brunt of poor infrastructure and services with inadequate access having a knock-on effect on their health, education, disposable income and time-savings (5.1, 5.4) [44]. Sanitation can support SDG5 as well as SDG16 (‘Peace, Justice and Strong Institutions’) regarding the need for safety, for example, through the development of female-friendly toilets, especially where women and girls are exposed to harassment ( Targets 5.2, 16.1) [45,46]. There is evidence of the relationship between sanitation and taboos around sexual and reproductive health, and the way lack of access to menstrual hygiene management facilities can affect girls’ school attendance, although further research is needed on this (Targets 5.1–2, 5.6) [47,48]. This link re-emerges in SDG4 (‘Quality Education’), which also presents linkages with infrastructure services and innovation

All Targets in SDG6 (‘Water and Sanitation’) call for action in relation to the delivery of ‘adequate and appropriate’ sanitation and hygiene infrastructure and supporting service systems. There are also possible synergies with all SDG6 Targets, for example, in the way treatment and safe disposal of human faeces and urine safeguards water systems (Targets 6.1, 6.3) [50,51]. Integrated Water Resource Management (IWRM) can benefit sanitation through reclamation of water/use of wastewater (Target 6.4, 6.5) [52], surface water and aquifer conservation (Target 6.6) [53]. However, possible trade-offs within SDG6 occur with the promotion of particular sanitation systems (e.g. flush toilets) that are water-intensive and could impede water security, increase household expenses, and impact on water resources (Targets 6.1–2, 6.4) [50,52]. This emphasises the need to challenge prevalent discourses where improved sanitation is associated with more water-intensive systems.

Sanitation development objectives are closely aligned with the food and energy sectors – SDG2 (‘Zero Hunger’) and SDG7 (‘Affordable and Clean Energy’) – due to the benefits of dealing with human waste as a resource for agricultural production (e.g. Targets 2.1–4 on treated wastewater used for irrigation, sewage sludge for farm productivity) and energy production (e.g. Targets 7.1–2 on human faeces valorisation for biogas production), but such practices are uncommon and typically small-scale and informal and require further evidence-building [54,55]. Synergies between sanitation and all Targets of SDG7 (‘Energy’) for which no trade-offs were identified highlights that
investment in sanitation would also benefit other forms of infrastructure that are critical for wellbeing [56,57]. The waste and energy nexus, for example, presents an opportunity to leverage investment across sectors and create multiple social and economic co-benefits [58]. Our definition of sanitation assumes implementation of safe systems covering the entire sanitation value chain, but there will be instances where unsafe disposal or re-use practices may lead to contamination of food and the environment. If such re-use and treatment options are not adequately implemented, this could lead to further contamination of water and soil and present a threat to human health [50,59]. SDG9 (‘Industry, Innovation and Infrastructure’) also recognises the value of resource-efficient systems and emphasises the need for developing and upgrading sanitation infrastructure that enables the valorisation of excreta in closed-loop systems (Targets 9.1, 9.4, 9.a) [60,61].

SDG9 demands investment into innovation, which in the sanitation sector could centre around innovative approaches to existing large-scale sanitation systems to include decentralised schemes. This can include green technologies but also ecological sanitation techniques, such as the development of green infrastructure for wastewater treatment (Targets 9.5, 9.b) [62,63]. Also, on wastewater management, there are four targets under SDG12 (‘Consumption and Production’) calling for change in sanitation infrastructure to re-use waste and thereby reduce pressure on natural resources (Target 12.2, 12.4–6). We identified evidence for different types of synergies to safeguard ecosystems, for example, where irrigation techniques or water-efficient toilets reduce the use of freshwater resources, and where the production of gas and electricity from faecal waste reduces pressure on fossil fuel reserves (Targets 7.2, 12.2, 12.5, 12.8) [61,64,65]. Links between sanitation and SDG13 (‘Climate Action’) include infrastructural change. In parallel to actions seeking to safeguard pressure on water resources, we identify, for example, that integrated sanitation interventions block transmission paths and reduce infection risks in flood-prone areas (Target 13.1) [66,67].

Our study confirms the fundamental role that sanitation has to play in supporting progress towards SDG11 (‘Sustainable Cities and Communities’) and SDG8 (‘Decent Work and Economic Growth’) as a basic service underpinning societal development. Sanitation has a vital role to play in protecting public health in cities as they expand rapidly (Targets 11.1, 11.3) [26–28]. Sanitation supports economic productivity (Targets 8.1–2) and eco-economic decoupling (Target 8.4) [68–71]. Sanitation and SDG8 also link through entrepreneurship, creativity and innovation (Target 9.3) as small and medium enterprises and research and development institutions play pivotal roles in the sanitation sector. However they face various institutional barriers such as access to affordable financing mechanisms and adequate infrastructure [72]. Sanitation action is required to achieve universal ‘decent work’ (Targets 8.5–8), including for sanitation workers – and particularly informal workers involved in faecal sludge management – who are not protected by health and safety measures while they operate in marginalised environments. While efforts are growing to address this challenge they remain ad-hoc and fragmented [73–75].

**Environment and natural resources**

Sanitation has a crucial role to play in protecting environmental resources and relates to SDG14 (‘Life Below Water’) and SDG15 (‘Life On Land’) in two important ways: in reducing pollution to conserve ecosystems; and in enhancing ecosystem services through safe re-use of excreta. The latter is important, because the nutrient content of excreta benefits soils and aquatic systems. On reduced pollution, safer or no waste disposal into the environment requires considering the entire sanitation chain rather than adopting a narrow focus on toilets, which is not sufficient to address environmental contamination. We therefore identify the range of actions required where untreated sewage pollutes coastal and marine areas (Targets 14.1–2, 14.5) [76,77], as well as terrestrial and inland freshwater ecosystems (15.1–5) [78]. On the re-use of excreta, published evidence has explored opportunities to restore degraded land and soils (15.2–5) [79–81], as well as to enrich water resources with nutrients (14.2, 14.7) [82,83]. Studies on nature-based solutions have proposed a range of techniques supporting the achievement of objectives in both environmental conservation and sanitation service provision, for example, through wetland conservation or the construction of artificial wetlands (15.1) [84,85].

Synergies were identified for several Targets in relation to ecosystem services and the livelihood opportunities they represent; for example, in aquaculture (Target 14.7) [59,82,86,87], and in sustainable tourism (Target 15.4) to limit the impact of the industry on ecosystems. Furthermore, the water, agricultural and energy sectors are concerned with pollution and waste management
Synergies and trade-offs between sanitation and the SDGs (Targets 2.1, 6.1, 6.3, 6.5–6, 7.a) [52,88–90], which is also an important issue tackled by SDG9 (‘Industry, Innovation and Infrastructure’) through Target 9.4 as mentioned in domain 2, and by SDG12 (‘Responsible Consumption and Production’) through Targets 12.2, 12.4–6 as mentioned in domain 3 [60,91,92]. A potential trade-off was identified with Target 15.8 on invasive species as non-native species may be introduced with certain types of sanitation systems (e.g. introduction of alien species through faeces containing seeds), where human waste is applied on soils as a source of nutrients, although no published research was identified to support this.

There is evidence of synergies with integrated climate action reducing environmental contamination from spillage during natural disasters, including that of resilient sanitation infrastructure mentioned in domain 2 (13.1). Building awareness on risks and impacts of climate change on sanitation on-site systems will help the implementation of measures such as the timely emptying of pit latrines and septic tanks in emergency settings to limit environmental impacts (13.3) [66,93]. Recent research has explored the potential of off-site composting of human waste on the reduction of greenhouse gas emissions in the context of container-based sanitation systems in slums, thereby articulating the links between sanitation, climate change, the environment and basic services (13.b, 15.1, 11.1) [94].

Governance and partnerships for the goals

There are multiple ways through which sanitation relates to the strengthening of institutional mechanisms (SDG17 ‘Partnerships for the Goals’) that can support the achievement of the rest of the SDG Targets. On finance mobilisation and allocation (Targets 17.1–5), there is recognition that the poorest countries receive proportionately less Official Development Assistance (ODA) and that water and sanitation-related ODA is poorly targeted (Target 17.2) [95]. Yet, ODA can sustainably support sanitation interventions on the ground as well as inform policy-making and regulations (Targets 17.2–5) [73,96–100]. Evidence of positive links between sanitation and SDG17 have also been identified in national policies and strategies which capitalise on their international relationships for exchange of sanitation-related information, knowledge, technology and finance (Targets 17.6–9) [101].

Trade-offs may also exist where practices advocated by the international development community set the path for certain practices that do not match local level aspirations or overlook existing local activities [102]. These trade-offs were also identified in other Goals as community needs and/or aspirations are not always reflected in national policy-contexts (e.g. for Targets 6.a, 12.7). Another trade-off relates to the potential of government taxes increasing the financial burden of households and preventing them from investing in sanitation (17.1). Besides, increasing taxes and revenues is not a guarantee that these are used to fund and sustain the expansion of sanitation infrastructures across countries [103]. Some of these challenges are related to the lack of additional finance to pay for sanitation systems that may be costlier than existing ones. Potentially stronger community participation through public–private–civil society partnerships could be a game-changer in the implementation of sanitation systems for which users are willing/able to pay (17.17, 5.5, 6.b, 11.3, 16.7) [104–106]. For example, adapting existing sanitation systems to build climate resilience will require a combination of additional finance and will need deeper participation of the users [107].

At national-level, policy coherence remains an important challenge that requires stronger collaboration between governmental institutions (Target 17.14) [108]. Beyond governments, the formation of strategic multi-stakeholder partnerships will be crucial to achieve the successful planning and implementation of sanitation interventions, including potential beneficiaries (Targets 17.16–17) [109,110]. This is particularly relevant in the context of climate resilience (SDG13) in relation to sanitation services which need to be part of national policies and planning (Target 13.2), and within which community participation is critical (Target 13b). Yet, there is significant uncertainty around climate change impacts, and this means that today’s investments may not result in climate-resilient sanitation systems. Thus, important trade-offs may emerge during the development and adoption of adaptation strategies (Target 13.1). Establishing partnerships will require exploring a range of business models that bring together multiple actors, and building capacity to plan and implement projects collaboratively across levels (Targets 17.4–9). High-quality, timely and reliable data management, including appropriate monitoring and evaluation systems will support the planning, implementation and measurement of progress for sanitation interventions (Targets 17.18–19) [95,111].
Discussion and recommendations

Our structured review process demonstrates that sanitation action is required to achieve all 17 SDGs. We have identified evidence of synergies between sanitation and 130 Targets out of a total of 169 across the Goals. Synergies exist between sanitation and all Targets that consider inclusivity, social diversity and human wellbeing. Hence, cross-sectoral thinking will result in using resources more effectively, thereby encouraging collaboration and reducing conflict over resources. For example, inclusive sanitation services which embed menstrual hygiene and baby wash management have a direct link with targets in SDG3 and SDG5 that explicitly recognise the diverse needs of girls and women, newborns and children, and vulnerable populations such as the disabled. The rights and dignity of the workforce engaged in sanitation service provision is highlighted through links with SDG9 and SDG10. However, many of the identified trade-offs emphasise possible barriers to inclusive interventions due to conflicting objectives at various scales of action, especially where individual aspirations are overlooked by city, national or global-level strategic agendas. This is as much to do with policy design not taking into account contextual concerns, as it is to do with difficulties encountered with policy implementation. While this study emphasises the need to strengthen governance systems for integrated and cross-sectoral action, this requires further efforts around contextual guidance and documentation which is a gap also identified by Scott et al. [112].

Due to the evidence-based methodology and structured process, our study was able to identify a higher number of linkages between sanitation and the SDG Targets compared to the 2017 SuSanA study referenced in the introduction [18], including less established ones. This concerns, for instance, evidence links between sanitation improvements and SDG10 on reduced inequalities (six Targets), and SDG4 on health, such as the reduction of maternal mortality, the decrease in mortality from non-communicable diseases and the promotion of mental health and wellbeing [113–115].

Wide-ranging and innovative solutions in the sanitation sector are required to achieve resource efficiency, reduction in environmental contamination and improved working conditions in low and middle-income countries, especially for those informally engaged in sanitation service delivery [116]. Meeting the principle of zero harm to the environment would require shifting the focus away from just the provision of toilets to an inclusion of the entire sanitation value chain to include safe sanitation systems. In addition to reducing environmental risk such solutions would also negate associated health risks (diarrhoeal diseases, etc.). Much more than other forms of infrastructure, adaptation and scaling up of sanitation services are highly contingent on and heavily influenced by socio-cultural practices [117]. Hence, adopting participatory approaches and the integration of local population's knowledge to support decision-making would go some way to develop sanitation solutions which are socio-culturally acceptable.

The synergies and trade-offs documented here are based on a high-level assessment of evidence globally which cuts across geographies, cultures and political contexts. While the global scope of our analysis highlights general implications for sustainable development of action in the sanitation sector it does not offer guidance regarding the degree to which these manifest in specific contexts. Context-specific reviews will be required for different types of sanitation systems to ensure proposed interventions are appropriate and locally relevant. Applying the methodology to concrete case studies will help expand the evidence base established here. Case studies can further help assess the suitability of various technical options for safe sanitation systems to local conditions, acceptance of safe sanitation solutions along the entire value chain to reduce environmental risk, identify complex trade-offs in context, and understand socio-cultural barriers in order to scale-up appropriate solutions. Evidence of the far-reaching impact of sanitation within countries will further provide opportunities to harmonise and leverage in-country investment for sanitation. This would support the development of guidelines and practical tools to enable diverse stakeholders to deliver safe and inclusive sanitation solutions appropriate for local contexts. Context-specific case studies could also include a cross-sectoral evaluation as policy makers often have to compare demands before allocating limited resources.

The following two sections provide recommendations specifically to decision-makers and practitioners involved in sanitation and related sectors regarding how to take the results of this study further. The third section offers suggestions for researchers to replicate this methodology and/or expand the evidence base on linkages between sanitation and the SDGs. The recommendations combine our findings from the study as well as the above-mentioned workshop with development practitioners.
To governmental institutions and policy makers: addressing the current institutional and financial fragmentation in sanitation provision will require holistic and integrated policies, underpinned by collaborative and participatory approaches. In most countries, sanitation services are included within public health or water resources ministries where there are multiple and conflicting demands on limited human and financial resources. Depending on the context, addressing the financing gap in sanitation requires either convergence of efforts across ministries or the creation of dedicated cross-sectoral nodal agencies to deliver meaningful sanitation outcomes. Current sanitation investments have been directed to the provision of physical infrastructure in the formal city and less focused on the delivery of services for low-income households and informal settlements [118]. Universalisation of sanitation will require a shift towards co-produced sanitation solutions and inclusive decision-making policies and processes that include the voices of potential users, including marginalised groups [25,119,120]. A range of actors are developing closed-loop systems which provide an opportunity for governmental institutions and policy makers to form inclusive and innovative partnerships.

To practitioners (including funding institutions, private enterprises, INGOs/NGOs and community-based organisations): there is a need to expand evidence on cross-sectoral and multi-level governance collaboration. Practitioners can play an important role in supporting evidence-driven approaches by documenting and disseminating the impact of integrated sanitation interventions. This can be done with support from researchers and used to leverage further funding, in particular for regions and communities currently bypassed by investment. Financing institutions play a fundamental role in supporting the development and scaling-up of innovative solutions for the delivery of adequate, equitable and dignified sanitation interventions through harmonising funding streams to achieve the wide-ranging benefits of sanitation investments evidenced in this study. The private sector, NGOs and community-based organisations will be instrumental in adapting our framework as a participatory monitoring and evaluation tool that can be used to holistically consider impacts of sanitation interventions, socio-cultural factors, and the acceptance of solutions.

To researchers: significant research is needed to analyse collaborative investment and intervention models to meet the SDGs. This is key to support practitioners whose resources are often limited to conduct such studies to develop documentation and expand the evidence base. It is crucial to apply the methodology set out in this study in a variety of contexts to build a compendium of case studies with research that reflects realities on the ground and that considers evidence in different languages and goes beyond what has already been published (e.g. verbal testimonies and unpublished data). Similar to Evans and Howard [121], we argue this would support an enriched evidence base and help to substantiate the wide-ranging synergies between sanitation and the SDGs for a variety of socio-political settings. This requires research that embraces the principles of transdisciplinarity and knowledge co-production with active participation from multiple actors including policy actors and end-users to incorporate and embed knowledge in concrete political, geographical and socio-economic settings [122].

Conclusion
Sanitation as a sector suffers from under-investment of resources. For governments with limited resources, the ability to harmonise efforts across ministries would leverage funding from multiple programmes and initiatives and open the possibility to pitch for funding from sources beyond the traditional sectoral funders. Through the established linkages between sanitation and the 2030 Agenda, this research demonstrates the wide-ranging benefits of sanitation, which extend beyond health across multiple sectors. The identification of synergies locates areas where cross-sectoral thinking will result in using resources more effectively, thereby encouraging collaboration and reducing conflict over resources.

Current sanitation policies and investments bypass marginalised communities and groups, particularly poor women and children and those with disabilities, which in practice has meant that their access to services are deficient at best. A lack of targeted and inclusive policies and actions for those groups impedes progress towards achieving SDG6 and hence all SDGs. In addition, specifically in marginalised areas (informal settlements) knowledge gaps on socially and culturally acceptable technical solutions appropriate for various complex settings result in policy gaps.
This study builds on the need to adopt holistic sanitation systems which consider the entire value chain from safe containment to transport, treatment, disposal and re-use of waste to broker wide reaching benefits and mitigate negative social and environmental impacts. Priority areas in sanitation research for the coming years include understanding and developing re-use and recovery technologies and practices to better integrate a sanitation chain that responds to the water–food–energy nexus. Acceptance of solutions, such as re-use and recovery of human waste, will require acknowledgement of socio-cultural and environmental factors to achieve the direct and tangible impacts that sanitation can have on people and their communities. Shifting the focus away from toilet-centric approaches to a holistic system approach will not only minimise environment risk but would also lead to better health outcomes in terms of reduced morbidity and mortality.

The synergies identified in our study recognise issues where cross-sector thinking would result in more effective use of financial resources, enhanced collaboration and reduced conflict in currently under-served settings. Notably, sanitation has a synergistic link with all or nearly all of the Targets of the Goals for poverty, education, gender, water, energy, industry/infrastructure and cities; this highlights potential synergistic funding opportunities. Given the complexity of the SDGs and the need to integrate multifaceted issues, including climate change, urbanisation, population growth and pressure on environmental resources, experts from different disciplines will need to work together with diverse societal actors to break down traditional silos whilst considering both centralised and decentralised sanitation systems. The methodology presented provides a mechanism that can expand our knowledge base to support the development of more holistic solutions bringing together research, practice and policy actors to create evidence-based policies and practices for integrated resource mobilisation and implementation. It paves the way for transdisciplinary research and practice that can foster inclusive and safe sanitation solutions for all through deeper explorations of context-specific case studies.

This research provides different stakeholders, including policy makers, funders, practitioners and researchers, with a replicable framework. This can advance knowledge and facilitate informed decision-making to enhance funding, planning and implementation of sanitation within transdisciplinary research and practice to achieve the 2030 Agenda. The evidence-base initiated here, while limited in scope and requiring further expansion, can be used as a starting point to leverage and harness investment in sanitation and other sectors to make a difference to the state of sanitation access and address the SDGs more effectively. Most importantly, this is a call for urgent action for everyone to change the status quo to ensure adequate, equitable and inclusive sanitation for all by 2030.
# Supporting information

## Appendix 1. Evidence base from the global review exercise

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---------------------------------------------------------------|-------------------------------------------------|----------------------------------|------------------------------------------|----------------|-----------------------------------------------|
| Goal 1: End poverty in all its forms everywhere                |                                                 |                                  |                                          |                |                                               |
| 1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day | 1                                              | 1                                | 1                                        | (A) Eradicating poverty will need to be supported by the provision of access to basic services which includes sanitation and hygiene services. (B) Multiple synergies between sanitation and income as poverty is strongly linked to poor human and environmental health which can be due to poor sanitation, while lack of access to adequate sanitation and hygiene is a driver of poverty. (C) But also evidence of trade-offs, for example, where improved access requires investment/enhanced expenses that adds financial burden at household level. | - Alkire S. How to measure the many dimensions of poverty? In: Organisation for Economic Co-operation and Development, editor: Development Co-operation Report 2013: Ending Poverty. OECD Publishing; 2013. | |
| 1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions | 1                                              | 1                                | 1                                        | (A) + (B) + (C) as per Target 1.1 | - Davis J, White G, Damodaron S, Thorstén R. Improving access to sanitation and hygiene will reduce vulnerability and support resilience-building. | |
| 1.3 Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable | 1                                              | 1                                | 1                                        | (A) Target calls for action in sanitation to achieve substantial coverage of the poor and the vulnerable. (B) Synergies where social health protection leads to increased access to sanitation and hygiene. | - Bachelet M. Social protection floor for a fair and inclusive globalization. Geneva: International Labour Office; 2011. | |
| 1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance | 1                                              | 1                                | 1                                        | (A) Target calls for action in sanitation considered a basic service. (B) Synergies by definition (i.e. increased access in sanitation means there is contribution to this target), also evidence that economic resources and other forms of property available to the poor and the vulnerable can lead to increased access to sanitation, including where there are gains in sanitation investment in tenanted dwellings. (C) Several trade-offs including where better sanitation infrastructure increases land and house market and thereby affects access to tenure. | - Davis J, White G, Damodaron S, Thorstén R. Improving access to water supply and sanitation in urban India: microfinance for water and sanitation infrastructure development. Water Sci Technol. 2008;58:887-91. | |
| 1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters | 1                                              | 1                                | 1                                        | (A) Target calls for action in sanitation which, as a basic service, directly influences vulnerability to economic, social and environmental shocks and disasters. (B) Evidence that improved access to sanitation and health will reduce vulnerability and support resilience-building | - Medland L, Cotton A, Bill B, Foundation MG. Urban Sanitation Research Programme: consolidated findings. Loughborough: Water, Engineering and Development Centre (WEDC); 2015. | |
### Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---|---|---|---|---|---|
| **1.a** Ensure significant mobilisation of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions | 1 | 1 | 1 | (B) Evidence that mobilisation of resources to eradicate poverty has led to improved sanitation | Wolf S. Does aid improve public service delivery? New World Econ. 2007;143:650–72. |
| **1.b** Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions | 1 | 1 | 1 | (B) Multiple synergies exist, for example, where the introduction of policy frameworks specifically tackling poverty and/or gender inequalities leads to improved access to sanitation which accelerates poverty eradication itself | - OECD. Making Poverty Reduction Work: OECD’s Role in Development Partnership. Paris: Organisation for Economic Co-operation and Development (OECD); 2005. |

### Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture

| Sub-target | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---|---|---|---|---|---|
| **2.1** By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round | 1 | 1 | 1 | (A) Target calls for action in sanitation for access to safe food, including food that is not contaminated by pathogens | - Newell DG, Koopmans M, Verhoef L, Duler E, Aldara-Kane A, Spong H, et al. Food-borne diseases – The challenges of 20 years ago still persist while new ones continue to emerge. Int J Food Microbiol. 2010;139:S3–S15. |
| **2.2** By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons | 1 | 1 | 1 | (A) Target calls for action in sanitation for access to safe food, including food that is not contaminated by pathogens | - Freeman MC, Garn JW, Sclar GD, Boisson S, Medlicott K, Alexander KT, et al. The impact of sanitation on infectious disease and nutritional status: a systematic review and meta-analysis. Int J Hyg Environ Health. 2017;220:928–49. |
| **2.3** By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment | 1 | 1 | 1 | (B) Synergies exist, for example, where treated sewage is used to increase yield production (e.g. excreta re-use to produce protein feeds for livestock using black soldier flies) and helps nourishing soils (e.g. composted excreta) | - Anderson JCM, Zehnder AJJB, Rockstrom J, Yang H. Potential impacts of water harvesting and ecological sanitation on crop yield, evaporation and river flow regimes in the Thukala River basin, South Africa. Agric Water Manag. 2011;98:1113–24. |

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## Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---------------------------------------------------------------|--------------------------------------------------|-----------------------------------------------|-----------------------------------------------|--------------------------------------------------|--------------------------------------------------|
| 2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality | 1 | 1 | 1 | (A) Target calls for action in production systems through sustainable practices, including water re-use | - Kramer S, Preneta N, Kilbride A. Thermophilic composting of human wastes in uncertain urban environments: a case study from Haiti. In: 36th WEDC International Conference: delivering water, sanitation and hygiene services in an uncertain environment. Nakuru: WEDC, 2013. p. 1–6. - Moya B, Parker A, Sakrabani R, Mesa B. Evaluating the efficacy of fertilisers derived from human excreta in agriculture and their perception in Antananarivo, Madagascar. Waste Biomass Valo. 2019;10:941–52. |
| 2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilisation of genetic resources and associated traditional knowledge, as internationally agreed | - Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries | - Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round | - Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility | |
| 2.a | | | | |
| 2.b | | | | |
| 2.c | | | | |
### Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---------------------------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------------------|-----------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| **Goal 3. Ensure healthy lives and promote wellbeing for all at all ages** | | | | | |
| **3.1** By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births | 1 | 1 | 1 | (A) Target calls for action in sanitation for women during and post-pregnancy, including for access to adequate and safe toilets and post-birth hygiene; (B) Multiple synergies, for example where the elimination of open defecation has led to safer pregnancy in some contexts | Padhi BK, Baker KK, Dutta A, Cumming O, Freeman MC, Salpather R, et al. Risk of adverse pregnancy outcomes among women practicing poor sanitation in rural India: a population-based prospective cohort study. PLoS Med. 2015;12:1-18. |
| **3.2** By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1000 live births and under-5 mortality to at least as low as 25 per 1000 live births | 1 | 1 | 1 | (A) Target calls for action in sanitation for environments that are safe from pathogens; (B) Multiple synergies, including in safe sanitation in hospitals, and for the development of hand-washing facilities and practices | Velleman Y, Mason E, Graham W, Benova L, Chopra M, Campbell OMRI, et al. From joint thinking to joint action: a call to action on improving water, sanitation, and hygiene for maternal and newborn health. PLoS Med. 2014;11:1-9. |
| **3.3** By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases | 1 | 1 | 1 | (A) Target calls for action for cleaner water, including through treatment of pathogens; (B) Multiple synergies, including in the development of treatment systems for wastewater that contains human waste | La Rosa G, Fratini M, della Libera S, Iaconelli M, Muscillo M. Emerging and potentially emerging diseases (EIDs), malaria, HIV/AIDS, and communicable diseases. Zoonoses Public Health. 2015;62:397–406. |
| **3.4** By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being | 1 | 1 | 1 | (A) Target calls for action where poor sanitation affects mental health and wellbeing and exposure to risks of non-communicable diseases (NCDs); (B) Evidence shows links between poor sanitation practices and chronic NCDs, for example, through soil-transmitted helminths, also between sanitation and psychological stress, showing synergies between sanitation interventions and NCDs | Mohana SR, Dhimal M, Chandralal PM, Adhikari B. Sanitation for all: the global opportunity to increase transgenerational health benefit and better understand the link between NCDs and NTDs, a scoping review. Trop Dis Travel Med Vaccines. 2017;3:1-17. |
| **3.5** Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol | 1 | 1 | 1 | (C) Trade-offs may exist where toilets are used as facilities for drug abuse | Wolfson-Stoffo B, Bennett AS, Elliott L, Curtis R. Drug use in business bathrooms: an exploratory study of manager encounters in New York City. Int J Drug Policy. 2017;39:69–77. |
| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---|---|---|---|---|---|
| 3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents | | | | | |
| 3.7 By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes | 1 | 1 | 1 | (A) Target calls for action in sanitation and hygiene in sexual and reproductive health care services (B) Multiple synergies for example, around menstrual hygiene management (MhM) | - WHO, Integrating sexual and reproductive health in WASH. The International Women’s Health Coalition (IUH), 2018. - WaterAid, Marie Stopes International Australia. Integrating menstrual health, water sanitation and hygiene, and sexual and reproductive health in Asia and the Pacific Region. WaterAid and Marie Stopes International Australia; 2016. |
| 3.8 Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all | 1 | 1 | 1 | (A) Target calls for action in sanitation and hand-washing services to achieve health coverage for all (B) Synergies since sanitation and hygiene interventions will participate in increasing health coverage | - Lavy V, Strauss J, Thomas D, de Vreyer P. Quality of health care, survival and health outcomes in Ghana. J Health Econ. 1996;15:333–57. - Haller L, Hutton G, Bartram J. Estimating the costs and health benefits of water and sanitation improvements at global level. J Water Health. 2007;5:467–80. |
| 3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination | 1 | 1 | 1 | (A) Target calls for action in sanitation where there is pollution caused by unsafe human waste disposal and leading to various illnesses and diseases (B) Multiple synergies exist, for example, with treatment, re-use and safe disposal of faeces and urine to reduce water and soil pollution and contamination | - Giusti L. A review of waste management practices and their impact on human health. Waste Manag. 2009;29:2227–39. - Montgomery MA, Elimelech M. Water and sanitation in developing countries: including health in the equation – Millions suffer from preventable illnesses and die every year. Environ Sci Technol. 2007;41:17–24. - Cairncross S, Valdmanis V. Water supply, sanitation and hygiene promotion. In: Disease control in developing countries. Washington D.C: The World Bank; 2006. p. 771–92. |

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- **Paper Title**: A review of waste management practices and their impact on human health.
  - **Authors**: Giusti L.
  - **Journal**: Waste Management.
  - **Year**: 2009.
  - **Volume**: 29.
  - **Pages**: 2227–39.

- **Paper Title**: Water and sanitation in developing countries: including health in the equation – Millions suffer from preventable illnesses and die every year.
  - **Authors**: Montgomery MA, Elimelech M.
  - **Journal**: Environmental Science & Technology.
  - **Year**: 2007.
  - **Volume**: 41.
  - **Pages**: 17–24.

- **Paper Title**: Disease control in developing countries.
  - **Authors**: Cairncross S, Valdmanis V.
  - **Publisher**: The World Bank.
  - **Location**: Washington D.C.
  - **Year**: 2006.
  - **Pages**: 771–92.
### Synergies and trade-offs between sanitation and the SDGs

**Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all**

| Sample References |
|-------------------|
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| Mahon T, Fernandes M. Lessons learned during public health response to cholera epidemic in Haiti and the Dominican Republic. Emerg Infect. Dis. 2011;17:2087–93. |
| Johnston-Robledo I, Christle JC. The menstrual mark: menstruation as social stigma. Sex Roles. 2013;68:9–18. |

**Goal 3. Ensure healthy lives and promote well-being for all at all ages**

| Sample References |
|-------------------|
| Abrahams N, Mathews S, Ramela P. Intersections of sanitation, sexual coercion and girls’ safety in schools. Menstrual Hygiene in South Asia: a neglected issue for WaSh (water, sanitation and hygiene) programmes. Gend Dev. 2010;18:99–113. |
| Mahon T, Fernandes M. Menstrual health management in East and Southern Africa: a review paper. in: Menstrual Health Management Symposium. Johannesburg: United Nations Population Fund, East and Southern Africa Regional Office; 2018. |
| Johnston-Robledo I, Christle JC. The menstrual mark: menstruation as social stigma. Sex Roles. 2013;68:9–18. |

**Goal 3. Ensure healthy lives and promote well-being for all at all ages**

| Sample References |
|-------------------|
| Adusia A. Sanitation and education. Am Econ J Appl Econ. 2017;9:23–59. |
| Mahon T, Fernandes M. Lessons learned during public health response to cholera epidemic in Haiti and the Dominican Republic. Emerg Infect. Dis. 2011;17:2087–93. |
| Johnston-Robledo I, Christle JC. The menstrual mark: menstruation as social stigma. Sex Roles. 2013;68:9–18. |

### Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---------------------------------------------------------------|---------------------------------|-------------------------------------------|---------------------------------------------|----------|-------------------|
| 3.e Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and Small Island Developing States | 1 | 1 | 1 | (A) Target calls for action in sanitation sector which includes actors who are part of the health workforce | Rowe G, Frewer LJ. Evaluating public-participation exercises: a research agenda. Sci Technol Hum Values. 2004;29:512–57. |
| 3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks | 1 | 1 | 1 | (A) Target calls for action in sanitation sector where there are important risks for disease transmission through faecal-oral routes | Tappero J, Tauxe R. Lessons learned during public health response to cholera epidemic in Haiti and the Dominican Republic. Emerg Infect. Dis. 2011;17:2087–93. |
| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---|---|---|---|---|---|
| 4.5 By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations | 1 | 1 | 1 | (A) + (B) as per Targets 4.1, 4.3 and 4.4 | - Esrey SA, Habicht JP. Maternal literacy modifies the effect of toilets and piped water on infant survival in Malaysia. Am J Epidemiol. 1988;127:1079–87. - Rotary. Water. Sanitation. hygiene. Education. Literacy. a guide to WaSh in Schools. Evanston: Rotary International; 2016. - Merchant AT, Jones C, Kiarie A, Kupka R, Fitzmaurice G, Herrera MG, et al. Water and sanitation associated with improved child growth. Eur J Clin Nutr. 2003;57:1562–8. |
| 4.6 By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy | 1 | 1 | 1 | (A) Target calls for action as sanitation where lack of facilities affects attendance and therefore limits literacy and numeracy achievements (B) Multiple synergies since attendance is linked to adequate and safe sanitation facilities in schools and therefore supports literacy and numeracy achievements; also where achieving literacy and numeracy participates in learning about sanitation and hygiene practices | - Esrey SA, Habicht JP. Maternal literacy modifies the effect of toilets and piped water on infant survival in Malaysia. Am J Epidemiol. 1988;127:1079–87. - Rotary. Water. Sanitation. hygiene. Education. Literacy. a guide to WaSh in Schools. Evanston: Rotary International; 2016. - Merchant AT, Jones C, Kiarie A, Kupka R, Fitzmaurice G, Herrera MG, et al. Water and sanitation associated with improved child growth. Eur J Clin Nutr. 2003;57:1562–8. |
| 4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of cultures’ contribution to sustainable development | 1 | 1 | 1 | (A) Education in relation to sanitation and hygiene is required in order to achieve this target (B) Evidence that education in relation to sanitation and hygiene participates in sustainable development, for example in relation to waste disposal, or that knowledge and skills around sustainable development change sanitation and hygiene practices | - Azadu S, Ofosuze I. The role of health education and sanitation in the control of helminth infections. Acta Trop. 2003;86:283–94. - Corcoran E, Niemann C, Baker E, Bos R, Osborn D, Savell H. Sick water? the central role of wastewater management in sustainable development: a rapid assessment. Vol. 30, Mine Water and the Environment. United Nations Environment Programme, UN-HABITAT, GRID-Arendal; 2010. |
| 4.a Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all | 1 | 1 | 1 | (A) + (B) as per Target 4.1 | |
| 4.b By 2020, substantially expand globally the number of scholarship available to developing countries, in particular least developed countries, Small Island Developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries | 1 | 1 | 1 | (A) Target calls for action in sanitation where poor conditions negatively affect teachers’ decisions of their teaching location (B) Possible synergies where teachers benefiting from trainings are introduced to health education that will benefit themselves and possibly communities in their home county or that toilets/safe facilities is a pull factor for teachers | - Kayuni H, Tambulutsa R. Teacher turnover in Malawi’s Ministry of Education: realities and challenges. Int Educ J. 2007;8:89–99. - Adukia A. Sanitation and education. Am Econ J Appl Econ. 2017;9:23–59. |
## Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | ReReasoning | Sample References |
|---------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------------|---------------------------------|------------|-----------------|
| 5.1 End all forms of discrimination against all women and girls everywhere | 1 | 1 | 1 | 1 | (A) Target calls for action in sanitation to end discrimination and recognise women and girls’ special needs. (B) Multiple synergies for example, in MHM where installation of private toilets or unisex toilets has decreased violence against women, where education around MHM has reduced bullying towards women, or increased personal hygiene habits. |
| 5.2 Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation | 1 | 1 | 1 | 1 | (A) Target calls for action in sanitation to eliminate violence against women and girls, for example in public toilets or in locations of open defecation. (B) Synergies, for example, where the introduction of flush toilets reduces labour for women at home (C) But also risks of trade-offs where introduced system represents more labour to women at home. |
| 5.3 Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation | 1 | 1 | 1 | 1 | (A) Target calls for action in sanitation to alleviate the burden put on certain women, for example, to take care of household toilets, or baby wash (B) Multiple synergies for example where the introduction of flush toilets reduces labour for women at home (C) But also risks of trade-offs where introduced system represents more labour to women at home. |
| 5.4 Recognise and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate | 1 | 1 | 1 | 1 | (A) Call for action in sanitation where poor conditions put barriers to women’s empowerment, for example, where a lack of facilities impedes everyday activities and prevents them from participating to public life (B) Synergies where improved access to sanitation pays attention to women’s needs so they have equal opportunities, or where the sanitation sector gives opportunities to women for them to participate and have access to leadership roles. (C) Possible trade-offs if further disproportionate responsibilities are added to women. |
| 5.5 Ensure women’s full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life | 1 | 1 | 1 | 1 | (A) Call for action in sanitation where poor conditions put barriers to women’s empowerment, for example, where a lack of facilities impedes everyday activities and prevents them from participating to public life (B) Synergies where improved access to sanitation pays attention to women’s needs so they have equal opportunities, or where the sanitation sector gives opportunities to women for them to participate and have access to leadership roles. (C) Possible trade-offs if further disproportionate responsibilities are added to women. |

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- Parkin P, Fu K, Parkin H, McRobie A, George G. Infrastructure provision, gender, and poverty in Indian slums. World Dev. 2015;66:568–69.
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| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---------------------------------------------------------------|-------------------------------------------------|---------------------------------|-------------------------------|-----------------|-------------------|
| 5.6 Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences | 1 | 1 | 1 | (A) Target calls for action as reproductive health can be threatened by lack of sanitation access (similar to 3.7). (B) As both the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action aim to expand access to reproductive health care, there are multiple synergies, for example, where improved access to sanitation services results in reduction of infections or where toilets improve sexual health | - WHO. Women and health: today's evidence tomorrow's agenda. Geneva: WHO; 2009. | |
| 6.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws | 1 | 1 | | (B) Possible synergies where equal rights to economic resources, access to decision-making by women in relation to land tenure and other forms of property ownership positively change the way sanitation matters are addressed | - Campbell OM. Benova L, Gon G, Afarsana K, Cumming O. Getting the basic rights – the role of water, sanitation and hygiene in maternal and reproductive health: a conceptual framework. Troo Med Int Health. 2015;20:252–67. - UN Women. Gender equality in the 2030 Agenda: gender responsive water and sanitation systems issue brief. New York: UN Women; 2018. | |
| 5.b Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women | 1 | 1 | | (B) Synergies where Information and Communications Technology (ICT) are used for women to exchange information and knowledge on sanitation-related matters such as menstruation and menopause | - Bhakta AN. Opening the doors to the hidden water, sanitation and hygiene needs of women from the onset of the perimenopause in urban Ghana. Loughborough: Loughborough University; 2011. | |
| 6.c Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels | 1 | 1 | | (A) Target calls for action in sanitation where policies do not recognise their needs and perpetuate inequality (B) Synergies, for example where policies require better access to toilets by women and girls, or promotes education around menstruation for girls and boys to reduce taboos and harassment | - Gross P. Coombes Y. editors. Sanitation and Hygiene in Africa: where do we stand? Analysis from the AfricanSanitation Conference, Kigali, Rwanda. London: IWA Publishing; 2014. | |

#### Goal 6. Ensure availability and sustainable management of water and sanitation for all

| 6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all | 1 | 1 | 1 | 1 | (A) Target calls for multiple actions in sanitation, for example, for safe water that is free of contaminants (B) Evidence of synergies, for example, in the way treatment and safe disposal of human faeces and urine improves the quality of water, also where ecological toilets reduce demand on water | - Haq G, Cambridge H. Exploiting the co-benefits of ecological sanitation.Curr Opin Environ Sustain. 2012;4:431–5. - BENEFIT E. Nguyen D, Lohmann T, Schmitt B, Schosseler P. Life cycle assessment of ecological sanitation system for small-scale wastewater treatment. Sci Total Environ. 2009;407:1506–16. - Nairn S. The flush toilet is ecologically mindless: think about it. Down to Earth. 2002;10:1–14. - Hutton G, Chase C. The knowledge base for achieving the sustainable development goal targets on water supply, sanitation and hygiene. Int J Environ Res Public Health. 2016;13:1–35. | |
| 6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations | 1 | 1 | 1 | 1 | (B) Synergies as per definition (C) Trade-offs exist if implemented sanitation systems are not relevant to context or not sustainable (e.g. where newly-built toilets are not matching the target population's needs, are not maintained over time, are not resilient to climate impacts, or where handwashing practices are not followed), including in emergency contexts where access to sanitation is achieved but making it dignified or long-lasting is challenging (e.g. in zones affected by war), or where external factors intervene (e.g. contamination occurs through contact with animals) | - Zambrano LD, Levy K, Menezes NP, Freeman MC. Human diarrhoea infections associated with domestic animal husbandry: a systematic review and meta-analysis. Trans R Soc Trop Med Hyg. 2014;108:313–315. - Briceno B, Civille A, Gerler P, Martinez S. Are there synergies from combining hygiene and sanitation promotion campaigns: evidence from a large-scale cluster-randomised trial in rural Tanzania. PLoS One. 2017;12:1–19. - Nawab B, Nyborg IJP, Eser KB, Jersey P. D. Cultural preferences in designing ecological sanitation systems in North West Frontier Province, Pakistan. J Environ Psychol. 2006;26:236–46. |
### Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------------------------|-----------------------------------------------|------------|-------------------|
| 6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimising release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally | 1                                                                 | 1                                           | 1                                             | (A) Target calls for direct action in sanitation<br>(B) Evidence to support multiple synergies, for example, where treatment and safe re-use of wastewater includes urine and human excreta<br>(C) Also evidence that some sanitation systems may be water-intensive as per described in 6.1 | - Grant SB, Saphores JD, Feldman DL, Hamilton AJ, Fletcher TD, Cook PLM, et al. Taking the ‘waste’ out of ‘wastewater’ for human water security and ecosystem sustainability. Science. 2012;337:681–6.<br>- Narain S. The flush toilet is ecologically mindless: think about it. Down to Earth. 2000;10:1–14. |
| 6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of fresh-water to address water scarcity and substantially reduce the number of people suffering from water scarcity | 1                                                                 | 1                                           | 1                                             | (A) Target calls for direct action in sanitation<br>(B) Evidence to support multiple synergies, for example, with the safe re-use of wastewater as per described in 6.3<br>(C) Also evidence that some sanitation systems may be water-intensive as per described in 6.1 | - Grant SB, Saphores JD, Feldman DL, Hamilton AJ, Fletcher TD, Cook PLM, et al. Taking the ‘waste’ out of ‘wastewater’ for human water security and ecosystem sustainability. Science. 2012;337:681–6.<br>- Narain S. The flush toilet is ecologically mindless: think about it. Down to Earth. 2000;10:1–14. |
| 6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate | 1                                                                 | 1                                           | 1                                             | (A) Target calls for action in sanitation to reduce pollution and discharge in water bodies<br>(B) Evidence that Integrated Water Resources Management (IWRM) principles can benefit sanitation, for example, through re-use of wastewater that includes urine and human excreta and vice versa | - Niemczynowicz J. Urban hydrology and water management – present and future challenges. Urban Water. 1999;1:1–14. |
| 6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes | 1                                                                 | 1                                           | 1                                             | (A) Target calls for multiple actions in sanitation, including through reduction of pollution, and the reuse of excreta and urine<br>(B) Evidence that the safe disposal of human excreta and urine is necessary or beneficial to ecosystems, for example, in conserving rivers and aquifers, and in providing nutrients to forests | - Hu GJ, Zhou M, Hou HB, Zhu X, Zhang WH. An ecological floating-bed made from dredged lake sludge for purification of eutrophic water. Ecol Eng. 2010;36:1448–58.<br>- Grant SB, Saphores JD, Feldman DL, Hamilton AJ, Fletcher TD, Cook PLM, et al. Taking the ‘waste’ out of ‘wastewater’ for human water security and ecosystem sustainability. Science. 2012;337:681–6.<br>- Foster S, Ali-Kadi M. Integrated Water Resources Management (IWRM): how does groundwater fit in? Hydrogeol J. 2012;20:341–5. |
| 6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies | 1                                                                 | 1                                           | 1                                             | (A) Target calls for action in relation to international cooperation and capacity-building in sanitation-related activities and programmes<br>(B) Multiple synergies where international cooperation and capacity-building benefits in-country sanitation systems to increase access<br>(C) Possible trade-offs where gaps exist between different actors favouring different options, for example, where local users reject what supporting countries propose to implement | - Mihandile AM, Pateronis W. Biogas technology research in selected sub-saharan African countries – A review. African J Biotechnol. 2009;8:116–25.<br>- BORDA. Annual Report 2013-2014. Bremen: BORDA; 2013.<br>- Paterson C, Mara D, Curtis T. Pro-poor sanitation technologies. Geoforum. 2007;38:901–7.<br>- Gopalal S, Rajan RS. Has foreign aid been effective in the water supply and sanitation sector? Evidence from panel data. World Dev. 2016;85:84–104. |
| 6.b Support and strengthen the participation of local communities in improving water and sanitation management | 1                                                                 | 1                                           | 1                                             | (A) Target calls for action to support and strengthen the participation of local communities in improving sanitation management<br>(B) Multiple synergies, for example in fostering local ownerships of sanitation systems leading to an increased access to locally adequate sanitation services<br>(C) Trade-offs as per Target 6.a or in causing arrangements that are socially disruptive and increase spatial fragmentation and inequalities, for example by adding burden on local communities that initially lack capacity to manage sanitation systems | - Minil D, Bartlett S. Co-production in cities: providing services, empowering communities, changing relationships. Vol. 38. London: Environment & Urbanization; 2018.<br>- Morello F, Aldi G, Ponzetto M, Rossati N, Tito Bozozi JP, Teller J. Challenges of water and sanitation service co-production in the global South. Environ Urban. 2018;30:425–43.<br>- Nawabi B, Nyberg ILP, Esser KB, Janssens PD. Cultural preferences in designing ecological sanitation systems in North West Frontier Province, Pakistan. J Environ Psychol. 2006;26:236–46. |
### Appendix. Continued

| A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
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| **Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all** |  |  |  |  |
| 7.1 By 2030, ensure universal access to affordable, reliable and modern energy services |  |  | (B) Multiple synergies, including with the development of waste-to-energy systems, for example, with biogas production using human faeces | - Gautam R, Baral S, Herat S. Biogas as a sustainable energy source in Nepal: present status and future challenges. Renew Sustain Energy Rev. 2009;13:248-62. - Fangzhou D, Zhenglong L, Shaqiqiang Y, Beiwen X, Hong L. Electricity generation directly using human feces wastewater for life support system. Acta Astronaut. 2011;68:1537–47. |
| 7.2 By 2030, increase substantially the share of renewable energy in the global energy mix |  |  | (A) Target calls for action in developing renewable energy which includes the production of biogas with human waste (B) Synergies as per Target 7.1 | -Arthur R, Baidoo MF, Antral E. Biogas as a potential renewable energy source: a Ghanaian case study. Renew Energy. 2011;36:1510-4. - Gautam R, Baral S, Herat S. Biogas as a sustainable energy source in Nepal, present status and future challenges. Renew Sustain Energy Rev. 2009;13:248-62. - Fangzhou D, Zhenglong L, Shaqiqiang Y, Beiwen X, Hong L. Electricity generation directly using human feces wastewater for life support system. Acta Astronaut. 2011;68:1537–47. |
| 7.3 By 2030, double the global rate of improvement in energy efficiency |  |  | (B) Various possible synergies to make sanitation technology more efficient, for example, treatment stations | -Abma WR, Driessen W, Haarthuis R, Van Loosdrecht MCM. Upgrading of sewage treatment plant by sustainable and cost-effective separate treatment of industrial wastewater. Water Sci Technol. 2010;61:1715–22. -Krzeminski P, Van Der Graaf JHJM, Van Lier JB. Specific energy consumption of membrane bioreactor (MBR) for sewage treatment. Water Sci Technol. 2012;65:380–82. -Hanak DP, Kolios AJ, Onabanjo T, Wagland ST, Patchigolla K, Fidalgo B, et al. Conceptual energy and water recovery system for self-sustained nano membrane toilet. Energy Convers Manage. 2016;126:352–61. |
| 7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology |  |  | (B) Synergies include international cooperation having enabled renewable energy development using human excreta and urine for energy production, knowledge exchange and subsequent investment in such type of energy infrastructure and technology | -Mithandale AM, Parsons W. Biogas technology research in selected sub-saharan African countries – a review. African J Biotechnol. 2009;8:116-25. |
| 7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable-energy services for all in developing countries, in particular least developed countries, small Island Developing States, and land-locked developing countries, in accordance with their respective programmes of support |  |  | (B) Synergies as per Target 7.1, with examples of research on domestic biogas production and self-sustained nano-membrane toilet | -Bond T, Templeton MR. History and future of domestic biogas plants in the developing world. Energy Sustain Dev. 2011;15:347–54. -Hanak DP, Kolios AJ, Onabanjo T, Wagland ST, Patchigolla K, Fidalgo B, et al. Conceptual energy and water recovery system for self-sustained nano membrane toilet. Energy Convers Manage. 2016;126:352–61. |
### Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---------------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------------|---------------------------------------------|-------------------------------------------|---------------------------------------------------------------|
| **Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all** | | | | | |
| **8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7% gross domestic product growth per annum in the least developed countries** | 1 | 1 | 1 | (A) Target calls for action in sanitation to sustain economic growth through investment in public health and sanitation systems to ensure productive citizens | - Cole MA, Neumayer E. The impact of poor health on total factor productivity. J Dev Stud. 2006;42:918–38. |
| | | | | (B) Evidence of multiple synergies, for example, on investment in sanitation and hygiene yields economic returns (e.g. by reducing health costs, return on investments in education) | - UN-Water. Sanitation is an investment with high economic returns. International year of sanitation. Geneva: UN-Water; 2008. |
| | | | | | - Van Minh H, Hung NV. Economic aspects of sanitation in developing countries. Environ Health Insights. 2011:53–70. |
| **8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors** | 1 | 1 | 1 | (A) Target calls for action in the sanitation sector to ensure the diversification and technological upgrade of sanitation systems for the achievement of higher economic productivity | - Roefs I, Meulman B, Vreeburg JHG, Spiller M. Centralised, decentralised or hybrid sanitation systems? Economic evaluation under urban development uncertainty and phased expansion. Water Res. 2017;109:274–86. |
| | | | | (B) Evidence that upgrading of sanitation systems, including through diversification and upgrading of infrastructural systems, and also management and financing systems lead to higher economic productivity, while higher economic productivity can lead to higher investment in sanitation for better access | - O'Keefe M, Lüthi C, Tumwebaze IK, Tobias R. Opportunities and limits to market-driven sanitation services: evidence from urban informal settlements in East Africa. Environ Urban. 2019;27:421–40. |
| **8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalisation and growth of micro-, small- and medium-sized enterprises, including through access to financial services** | 1 | 1 | 1 | (A) Target calls for policies and finance that support job creation, entrepreneurship and innovation in the sanitation sector | - Scott P, Forte J, Mazaau A. Bankers and opportunities for sanitation SMEs: a study of the wider market system in Ghana. London: WSPU; 2012. |
| | | | | (B) Evidence that policies for sanitation services have boosted the sector, for example, through partnerships with small and medium-sized enterprises (SMEs) | - Gacouris J. Recognising and dealing with informal influences in water and sanitation services delivery. London: WSPU; 2012. |
| | | | | (C) But also evidence that certain policies may negatively affect workers in the sanitation sector (e.g. impeding informal workers, increased competitiveness) | - Jeppesen S. Enhancing competitiveness and securing equitable development: can small, micro, and medium-sized enterprises (SMEs) do the trick? Dev Pract. 2006;16:463–74. |
| **8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead** | 1 | 1 | 1 | (A) Action required for decoupling in re-use/recycling/valorisation of human waste | - Simha P, Ganesapillai M. Ecological sanitation and nutrient recovery from human urine: how far have we come? A review. Sustain Environ Res. 2017;27:107–16. |
| | | | | (B) Synergies are found where circular economy systems are developed in sanitation and support decoupling | - Lüthi C, McConville J, Norström A, Panesar A, Ingle R, Saywell D, et al. Rethinking Sustainable Sanitation for the Urban Domain. Proceedings of the Water Environment Federation; 2010. |
## Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---------------------------------------------------------------|---------------------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| 8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value | 1 | 1 | 1 | (A) Target calls for action as sanitation systems are required at the workplace in a way they provide decent jobs for all | Chandler TD. Sanitation privatization and sanitation employees’ wages. J Labor Res. 1994;15:137–53. |
| | | | | (B) Evidence that development of the sanitation sector creates employment and supports equal pay, also that improvements in the sanitation sector will increase employability of all women and men, including young people and persons with disabilities | Beagent T. Water and sanitation investments create evidence for trade-offs with sanitation employees' wages. J Labor Res. 1994;15:137–53. |
| 8.6 By 2020, substantially reduce the proportion of youth not in employment, education or training | 1 | 1 | 1 | (A) and (B) as for Target 8.5 | Same as per Target 8.5 |
| 8.7 Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms | 1 | 1 | | (B) Eradication of forced labour of children involved in sanitation systems (e.g. pit emptying) will participate in making a sector that is equitable and dignified | Obeng-Odoom F. The future of our cities. Cities. 2009;26:49–53. |
| 8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment | 1 | 1 | 1 | (A) The target calls for sanitation workers to work in safe and secure working environments | Steinmann P, et al. Psychosocial stress associated with sanitation practices: experiences of women in a rural community in India. J Water Sanitation Hyg Dev. 2015;5:115–26. |
| 8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products | 1 | 1 | | (B) Evidence of tourism impacting sanitation systems, as well as unsafe sanitation systems impacting the sustainability of tourism, therefore synergies have been identified on both sides for their potential to improve the other | Klein RA. Responsible cruise tourism: issues of cruise tourism and sustainability. J Hosp Tour Manag. 2011;18:107–16. |
| 8.10 Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all | 1 | 1 | | (B) Evidence of tourism impacting sanitation systems, as well as unsafe sanitation systems impacting the sustainability of tourism, therefore synergies have been identified on both sides for their potential to improve the other | Van Dijk MP, Etajak S, Mwalwega B, Ssempebwa J. Financing sanitation and cost recovery in the slums of Dar es Salaam and Kampala. Habitat Int. 2014;43:206–13. |
| 8.a Increase Aid for Trade support for developing countries, in particular least developed countries, including through the Enhanced Integrated Framework for Trade-Related Technical Assistance to Least Developed Countries | 1 | 1 | | (C) Aid for Trade excludes the financing of sanitation infrastructure which may limit progress in sanitation | Hoekman B, Wilson JS. Aid for trade: building on progress today for tomorrow’s future. In: Fardoust S, Kim Y, Sepulveda C, editors. Postcrisis growth and development: a Development Agenda for the G-20. Washington DC: the International Bank for Reconstruction and Development/The World Bank; 2011. |
## Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---|---|---|---|---|---|
| **8.b** By 2020, develop and operationalise a global strategy for youth employment and implement the Global Jobs Pact of the International Labour Organisation | | | | | |
| **Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation** | | | | | |
| **9.1** Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all | 1 | 1 | 1 | 1 | - Beyene H. Sanitation infrastructure sustainability challenges case study: Ethiopia. In: Bongartz P, Vernon N, Fox J, editors. Sustainable sanitation for all: experiences, challenges and innovations. Rugby: Practical Action Publishing; 2016. - Howard G, Pedley S, Barrett M, Naulegea M, Johal K. Risk factors contributing to microbiological contamination of shallow groundwater in Kampala, Uganda. Water Res. 2003;37:3421–9. - Sahasrabuddhe V. Making villages open defecation free: Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation. New Delhi; 2015. - Parikh P, Parikh H, Microbe A. The role of infrastructure in improving human settlements. Proc Inst Civ Eng Urban Des Plan. 2012;166:101–18. |
| **9.2** Promote inclusive and sustainable industrialisation and, by 2030, significantly raise industry’s share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries | 1 | | 1 | | - Kontish PH. Urban sanitation and health in the developing world: remembering the nineteenth century industrial nations. Health Place. 2009;15:69–78. |
| **9.3** Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets | 1 | | 1 | | - Scott P, Forte J, Maseau A. Barriers and opportunities for sanitation SMEs: a study of the wider market system in Ghana. London: Water & Sanitatin for the Urban Poor; 2017. - Tremont S. Small-scale finance for water and sanitation. Stockholm; 2012. - Rahman N. Adapting and replicating a proven partnership model for urban sanitation: SWEEP in Chittagong. London: Water & Sanitation for the Urban Poor; 2018. |
| **9.4** By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities | 1 | | 1 | 1 | - Gauntt R, Baral S, Heerat S, Bhogas as a sustainable energy source in Nepal: present status and future challenges. Renew Syst Energy Rev. 2009;13:248–52. - Fangzhou D, Zhenglong L, Shaoyang Y, Biechen X, Hong L. Electricity generation directly using human feces wastewater for life support system. Acta Astronaut. 2011;68:1537–47. - Andersson K, Dickin S, Rosemarien A. Towards “sustainable” sanitation: challenges and opportunities in urban areas. Sustain. 2016:6:1099. |
| **9.5** Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending | 1 | | 1 | | - Zhou X, Li Z, Zheng T, Yan Y, Li P, Olden EA, et al. Review of global sanitation development. Environ Int. 2018;120:246–61. |
### Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---------------------------------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------|---------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| 9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and Small Island Developing States | 1 | 1 | 1 | (A) The target calls for support to countries in need for sustainable and resilient sanitation infrastructure through financial, technological and technical support | - Botting MJ, Porbeni EO, Joffres MR, Johnston BC, Black RE, Mills EJ. Water and sanitation infrastructure for health: the impact of foreign aid. Global Health. 2010;6:12. - Gopalan S, Rajan RS. Has Foreign aid been effective in the water supply and sanitation sector? Evidence from panel data. World Dev. 2016;85:84–104. |
| 9.b Support domestic technology development, research and innovation in developing countries, including by creating a conducive policy environment for, inter alia, industrial diversification and value addition to commodities | 1 | 1 | 1 | (A) Target calls for support for domestic technological development, research and innovation in sanitation systems | - Murphy HM, McBean EA, Farahbakhsh K. Appropriate technology – a comprehensive approach for water and sanitation in the developing world. Techno Soc. 2009;31:155–67. - Diga K. Mobile cell phones and poverty reduction: technology spending patterns and poverty level change among households in Uganda. In: Workshop on the Role of Mobile Technologies in Fostering Social Development. São Paulo; 2008. - Parker A. Membrane technology plays key role in waterless hygienic toilet. Membr Technol. 2014;12:8. |
| 9.c Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020 | 1 | 1 | 1 | (B) Evidence of improved sanitation through phone applications used to pay for sanitation services, use of phone apps for early warnings to empty latrines and tanks, manuals consultable on phones and training in humanitarian sector | - GSMA. Loos et al. Digitising the container-based sanitation value chain in Madagascar [Online]. 2017. - Water & Sanitation for the Urban Poor. the PULa app: a customer acquisition and tracking tool for vacuum tanker businesses. London; 2017. - Diga K. Mobile cell phones and poverty reduction: technology spending patterns and poverty level change among households in Uganda. In: Workshop on the Role of Mobile Technologies in Fostering Social Development. São Paulo; 2008. |

**Goal 10. Reduce inequality within and among countries**

| 10.1 By 2030, progressively achieve and sustain income growth at the bottom 40% of the population at a rate higher than the national average | 1 | 1 | 1 | 1 | (A) Target calls for action in sanitation services to sustain income growth | - Cole MA, Neumayer E. The impact of poor health on total factor productivity. J Dev Stud. 2006;42:918–38. - UN-Water. Sanitation is an investment with high economic returns. International year of sanitation. Geneva; 2008. - Whittington D, Laura DT, Wright AM, Choe K, Hughes JA, Svama V. Household demand for improved sanitation services in Kumasi, Ghana: a contingent valuation study. Water Resour Res. 1993;29:1359–60. |
| 10.2 By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status | 1 | 1 | 1 | 1 | (A) Target calls for action in sanitation services for inclusion of all | - DeVries K, Rico A. Empowerment in action: savings groups improving community water, sanitation, and hygiene services. Enter Dev Microfinance. 2015;26:34–44. - Dankelman I, Muylwijk J, Wendland C, Margriet S. Making sustainable sanitation work for women and men: integrating a gender perspective into sanitation initiatives. Utrecht; 2009. |
### Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---------------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------------|---------------------------------------------|----------------|-------------------|
| **10.3** Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard | 1 | 1 | 1 | 1 | (B) Multiple possible synergies include toilet construction laws, policies and practices that particularly target the poorest, or women and girls. | - Van De Lande L, Ghazi B, Sanghera J. Eliminating discrimination and inequalities in access to water and sanitation. Geneva: UN-Water; 2015. |
| **10.4** Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality | 1 | 1 | 1 | 1 | (A) Target calls for action in sanitation for inclusive policies to meet workers’ needs. | - Jeffreys S. The politics of the toilet: a feminist response to the campaign to “degender” a women’s space. Women’s Stud Int Forum. 2014;45:42–51. |
| **10.5** Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations | 1 | 1 | 1 | 1 | (B) Synergies where social protection policies ensure minimum sanitation for the most vulnerable, or regulations that specifically target the sanitation labour market and protect sanitation workers from precarious working conditions. | - Samar V. The right to privacy and the right to use the bathroom consistent with one’s gender identity. Duke J Gender Law Policy. 2016;24:53–59. |
| **10.6** Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions | 1 | 1 | 1 | 1 | (C) Also potential trade-offs if ODA comes with certain conditions which do not match local population’s aspirations (even if conditions are in accordance with national plans), for example, ending open defecation, or promoting sewers versus on-site sanitation. | - Bastable A, Russell L. Gap analysis in emergency water, sanitation and hygiene promotion. Humanitarian Innovation Fund. Oxford GB; 2013. |
| **10.7** Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies | 1 | 1 | 1 | 1 | (B) Synergies exist if Official Development Assistance (ODA) is targeted towards achieving access to sanitation. | - Coffey D, Gupta A, Hari P, Khurana N, Spears D, Srivastav N, et al. Revealed preference for open defecation: evidence from a new survey in rural North India. Econ Polit. 2014;XLIX:43–55. |
| **10.a** Implement the principle of special and differential treatment for developing countries, in particular least developed countries, in accordance with World Trade Organization agreements | 1 | 1 | 1 | 1 | (B) Also potential trade-offs if ODA comes with certain conditions which do not match local population’s aspirations or are in conflict with national plans. | - Cha S, Manikadi PM, Bhag MS, Lee Y, Jin Y. Trends of improved water and sanitation coverage around the world between 1990 and 2010: Inequality among countries and performance of official development assistance. Glob Health Action. 2017;10:321710. |
| **10.b** Encourage official development assistance and financial flows, including foreign direct investment, to States where the need is greatest, in particular least developed countries, African countries, Small Island Developing States and land-locked developing countries, in accordance with their national plans and programmes | 1 | 1 | 1 | 1 | (C) Potential trade-offs if ODA comes with certain conditions which do not match local population’s aspirations or are in conflict with national plans. | - Koonan S. Background note on prohibition of manual scavenging and protection of the rights of sanitation workers in India. In: Workshop on Realising the Right to Sanitation – International and Comparative Perspectives. London: Law, Environment & Development Centre (EDC); 2013. |
Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
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| 10.e By 2030, reduce to less than 3% of the transaction costs of migrant remittances and eliminate remittance corridors with costs higher than 5% | 1 | 1 | 1 | 1 | (4) Target calls for action in sanitation (a basic service) by definition in order to provide services of containment, transport, treatment and safe disposal or re-use of wastes and, particularly in low-income areas which remain under-served or un-served. (5) Synergies, for example, where access to sanitation contributes to slum upgrading and delivers further benefits from knock-on impacts on housing stock. (C) Trade-offs exist, for example if upgrading does not actually lead to adequate, equitable, dignified sanitation, or if community-level sanitation is not meeting individual aspirations. | Bartram J, Charles K, Evans B, O'Hanlon L, Pedley S. Commentary on community-led total sanitation and human rights: should the right to community-wide health be won at the cost of individual rights? J Water Health. 2012;10:499–503. | - Parikh P, Parikh H, Micobie A. The role of infrastructure in improving human settlements. Proc Inst Civ Eng Urban Dev Plan. 2012;166:101–18. - Dodman D, Leck H, Rusca M, Colenbrander S. African urbanisation and urbanism: implications for risk accumulation and reduction. Int J Disaster Risk Reduct. 2017;26:7–15. |
| 11.1 Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable | By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums | 1 | 1 | 1 | 1 | (4) Target calls for action in sanitation (a basic service) by definition in order to provide services of containment, transport, treatment and safe disposal or re-use of wastes and, particularly in low-income areas which remain under-served or un-served. (B) Evidence of tourism impacting sanitation systems, as well as unsafe sanitation systems impacting the sustainability of tourism, therefore synergies have been identified on both sides for their potential to improve the other | Raghumun G, Tolet and Tains. Ahmadabad: Indian Institute of Management; 2008. - Vegad D, Paruthi S. Sewage disposal system for trains: current system and future prospects. Int J Emerg Technol. 2017;8:94–6. | |
| 11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons | 1 | 1 | 1 | (4) Target calls for action in sanitation (a basic service) by definition in order to provide services of containment, transport, treatment and safe disposal or re-use of wastes and, particularly in low-income areas which remain under-served or un-served. (B) Evidence of tourism impacting sanitation systems, as well as unsafe sanitation systems impacting the sustainability of tourism, therefore synergies have been identified on both sides for their potential to improve the other | Dodman D, Leck H, Rusca M, Colenbrander S. African urbanisation and urbanism: implications for risk accumulation and reduction. Int J Disaster Risk Reduct. 2017;26:7–15. - Shirazi, Cumming O, Brown J, Muneme B, Nala R, Shirazi T, Brown J, Muneme B, Nala R. The role of social capital: findings from an urban sanitation intervention in Maputo, Mozambique. Int J Environ Res Public Health. 2018;15:1–15. - Nance E, Oortolano L. Community participation in urban sanitation: experiences in Northeast Brazil. J Plan Educ Res. 2007;26:284–300. | |
| 11.3 By 2030, enhance inclusive and sustainable urbanisation and capacity for participation, integrated and sustainable human settlement planning and management in all countries | 1 | 1 | (4) Target calls for action in sanitation (a basic service) by definition in order to provide services of containment, transport, treatment and safe disposal or re-use of wastes and, particularly in low-income areas which remain under-served or un-served. (B) Evidence of tourism impacting sanitation systems, as well as unsafe sanitation systems impacting the sustainability of tourism, therefore synergies have been identified on both sides for their potential to improve the other | Dodman D, Leck H, Rusca M, Colenbrander S. African urbanisation and urbanism: implications for risk accumulation and reduction. Int J Disaster Risk Reduct. 2017;26:7–15. - Shirazi, Cumming O, Brown J, Muneme B, Nala R, Shirazi T, Brown J, Muneme B, Nala R. The role of social capital: findings from an urban sanitation intervention in Maputo, Mozambique. Int J Environ Res Public Health. 2018;15:1–15. - Nance E, Oortolano L. Community participation in urban sanitation: experiences in Northeast Brazil. J Plan Educ Res. 2007;26:284–300. | |
| 11.4 Strengthen efforts to protect and safeguard the world’s cultural and natural heritage | 1 | 1 | 1 | (4) Target calls for action in sanitation (a basic service) by definition in order to provide services of containment, transport, treatment and safe disposal or re-use of wastes and, particularly in low-income areas which remain under-served or un-served. (B) Evidence of tourism impacting sanitation systems, as well as unsafe sanitation systems impacting the sustainability of tourism, therefore synergies have been identified on both sides for their potential to improve the other | Huyapane GP, Thapa B. Perceptions of environmental impacts of tourism: a case study at CAAP. Nepal. Int J Sustain Dev World Ecol. 2006;13:51–61. - Parzial MG, Nunes Menegassê Waisiçau L, Uliain A, Antunes Arania PR, Martinho Gonçalves J. Environment, tourism and land use planning – Riachinho Basin, Brazil. Environ Manag Health. 2001;12:57–66. - Klein RA. Responsible cruise tourism: issues of cruise tourism and sustainability. J Hosp Tour Manag. 2011;18:107–16. | |
| 11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product | 1 | 1 | 1 | (4) Target calls for action in sanitation (a basic service) by definition in order to provide services of containment, transport, treatment and safe disposal or re-use of wastes and, particularly in low-income areas which remain under-served or un-served. (B) Evidence of tourism impacting sanitation systems, as well as unsafe sanitation systems impacting the sustainability of tourism, therefore synergies have been identified on both sides for their potential to improve the other | Israel M. Water and sanitation standards in humanitarian action. Turkish J Emerg Med. 2015;15:27–33. - Sherpa AM, Kooi Stolpe T, Zürbògg C, Clasé G. Vulnerability and adaptability of sanitation systems to climate change. J Water Clim Change. 2014;5:487–95. | |
### Reasoning

#### C: Trade-offs between the target and sanitation

Bartram J, Charles K, Evans B, O’hanlon L, Pedley S. Commentary on community-led total sanitation and human rights: should the right to community-wide health be won at the cost of individual rights? *J Water Health* 2012;10:499–503.

Johannessen Å, Rosemarin a, Thomallis F, Gerger Swartling Å, Stenström t, Vulturius G. Strategies for building resilience to hazards in water, sanitation and hygiene (WaSh) systems: the role of public private partnerships. *Int J Disaster Risk Reduct.* 2014;10:102–15.

Bakram J, Charles K, Evans B, O’Hanlon L, Pedley S. Commentary on community-led total sanitation and human rights: should the right to community-wide health be won at the cost of individual rights? *J Water Health.* 2015;10:499–503.

Conin AA, Headley AW, Gilson J, Beslin N, Komou FK, Halidin L, et al. Urbanisation effects on groundwater chemical quality: findings focusing on the nitrate problem from 2 African cities reliant on on-site sanitation. *J Water Health.* 2007;5:441–54.

Winker M, Vinnerås B, Muskolus a, Arnold U, Clemens J. Fertiliser products from new sanitation systems: their potential values and risks. *Bioresour Technol.* 2009;100:4090–6.

Spångberg J, Tidåker P, Jönsson H. Environmental impact of recycling nutrients in human excreta to agriculture compared with enhanced wastewater treatment. *Sci Total Environ.* 2014;493:209–19.

### Sample References

#### Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---|---|---|---|---|---|
|   | Yes | Yes | Yes | Multiple synergies, for example, in building resilient sanitation infrastructure, in triggering early warnings to empty latrines, and, from a social learning perspective, in developing management systems that are less exposed to risks. | No references provided. |
| 11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management | Yes | Yes | Yes | Multiple synergies, for example, in building resilient sanitation infrastructure, in triggering early warnings to empty latrines, and, from a social learning perspective, in developing management systems that are less exposed to risks. | No references provided. |
| 11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities | Yes | Yes | Yes | Multiple synergies including in the way green and public spaces are developed so they provide nature-based water treatment systems. | No references provided. |
| 11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning | Yes | Yes | Yes | Multiple synergies as actions in sanitation can contribute to rendering cities and human settlements more inclusive if special needs are addressed, resource efficient (e.g. with climate-proof sanitation technologies). | No references provided. |
| 11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels | Yes | Yes | Yes | Multiple synergies as actions in sanitation can contribute to rendering cities and human settlements more inclusive if special needs are addressed, resource efficient (e.g. with climate-proof sanitation technologies). | No references provided. |
| 11.e Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilising local materials | Yes | Yes | Yes | Multiple synergies as actions in sanitation can contribute to rendering cities and human settlements more inclusive if special needs are addressed, resource efficient (e.g. with climate-proof sanitation technologies). | No references provided. |
### Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---------------------------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------------------|-----------------------------------------------|----------|------------------|
| Goal 12. Ensure sustainable consumption and production patterns |                                                                              |                                               |                                               |          |                  |
| 12.1 Implement the 10-year framework of programmes on sustain-able consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries | 1                                                                            | 1                                             | 1                                             | (A) Target calls for action in sanitation, for enhancement of ecosystems but also for conservation (B) Multiple synergies exist, for example, where water saving toilets reduce the use of water resources, production of gas and electricity from faecal waste to reduce pressure on fossil fuel reserves. | Alfi S, Alnahhal S, Alrakhl S. Developing an integrated sustainable sanitation system for urban areas: Gaza Strip case study. Procedia CIRP; 2015;26:767–74. |
| 12.2 By 2030, achieve the sustainable management and efficient use of natural resources | 1                                                                            | 1                                             | 1                                             | (A) Target calls for action in sanitation, for enhancement of ecosystems but also for conservation (B) Multiple synergies exist, for example, where water saving toilets reduce the use of water resources, production of gas and electricity from faecal waste to reduce pressure on fossil fuel reserves. | Cordell D, Rosemarin A, Schröder JJ, Smil AL. Towards global phosphorus security: a systems framework for phosphorus recovery and reuse options. Chemosphere, 2011;84:747–58. |
| 12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses |                                                                              |                                               |                                               |          |                  |
| 12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimise their adverse impacts on human health and the environment | 1                                                                            | 1                                             | 1                                             | (A) Target calls for action towards waste management, which includes human excreta and urine (B) Multiple synergies as per Target 12.2 | Asano T, Levine AD. Wastewater reclamation, recycling and reuse: past, present, and future. Water Sci Technol. 1996;33:1–14. |
| 12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse | 1                                                                            | 1                                             | 1                                             | (A) Target calls for action in waste management which includes human excreta and urine (B) Multiple synergies, including where human waste is treated through natural systems (as in 12.2) and re-used for energy production (as in 7.1) or for irrigation (as in 2.3) | Fangzhou D, Zhenglong L, Shaoqiang Y, Beiwen X, Hong L. Electricity generation directly using human feces wastewater for life-support system. Acta Astronaut. 2011;68:1537–47. |
| 12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle | 1                                                                            | 1                                             | 1                                             | (A) Target calls for action by companies in their management of human waste (B) Synergies where human waste is internally valorised in a closed-loop system (e.g. energy production, irrigation) | Gensch R. Agriculture and sanitation. Urban Agric. 2008;20:38–40. |
| 12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities | 1                                                                            | 1                                             | 1                                             | (B) Synergies exist where procurement practices encourage the use of sustainable sanitation goods and services. | Econ. Assessing the impact of public sector procurement on competition. London: Econ; 2004. |

Sample References:
- Afifi S, Alnahhal S, Alrakhl S. Developing an integrated sustainable sanitation system for urban areas: Gaza Strip case study. Procedia CIRP; 2015;26:767–74.
- Cordell D, Rosemarin A, Schröder JJ, Smil AL. Towards global phosphorus security: a systems framework for phosphorus recovery and reuse options. Chemosphere, 2011;84:747–58.
- Mshandete AM, Parawira W. Biogas technology research in selected sub-saharan African countries – a review. African J Biotechnol. 2009;8:116–25.
- Asano T, Levine AD. Wastewater reclamation, recycling and reuse: past, present, and future. Water Sci Technol. 1996;33:1–14.
### Synergies and trade-offs between sanitation and the SDGs: UCL OPEN

#### Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------------------------|---------------------------------------------|------------------------------------------------|------------------------------------------------|
| **12.b** (By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature) | | | | (C) Potential trade-offs include where these procurement practices set the path for certain practices that are not matching aspirations at local level, or overlook existing local activities | Rheinländer T, Samuelson H, Daigaard A, Konradten F. Hygiene and sanitation among ethnic minorities in Northern Vietnam: does government promotion match community priorities? Soc Sci Med. 2010;71:994–1001. |
| **12.a** (Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production) | | | | (B) Synergies where knowledge of sustainable sanitation systems expands and reduces pressure on natural systems | Lamichhane KM, Babcock RW. Survey of attitudes and perceptions of urine-diverting toilets and human waste recycling in Hawaii. Sci Total Environ. 2013;443:749–56. |
| | | | | (C) Potential trade-offs include where these procurement practices set the path for certain practices that are not matching aspirations at local level, or overlook existing local activities | Euler H, Albreo P. Application of ecosan principles through public-private partnership projects – prospects and limitations. In: Werner G, et al., editor. 2nd International Symposium. Eschborn: IWA and GTZ; 2004. |
| **12.b** (Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products) | 0 | 0 | | | |
| **12.c** (Rationalise inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimising the possible adverse impacts on their development in a manner that protects the poor and the affected communities) | | | | (B) Synergies where sustainable sanitation systems (e.g. ecological that do not add pressure on natural resources) are developed as a result of strengthened scientific and technological capacity | Katuuka AY, Ronteltap M, Niwagaba CB, Foppen JWA, Kansiime F, Lens PNL. Sustainable sanitation technology options for urban slums. Biotechnol Adv. 2012;30:964–78. |
| | | | | (B) Synergies where knowledge of sustainable sanitation systems expands and reduces pressure on natural systems | Kengne IM, Dodane P-H, Akoa A, Kone D. Vertical-flow constructed wetlands as sustainable sanitation approach for faecal sludge dewatering in developing countries. Desalination. 2009;248:291–7. |
| **Goal 13. Take urgent action to combat climate change and its impacts** | | | | (A) Target calls for action as climate change impacts increasingly require adaptive sanitation systems (e.g. climate-proof infrastructure where there are sanitation-related contamination risks during floods or droughts, management systems that can trigger early warnings) | Lipton M. Health and Sanitation Aspects of Flood Management. Integrated flood management tools series. 2015. |
| **13.1** (Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries) | 1 | 1 | 1 | 1 | 1 | (A) Target calls for action as climate change impacts increasingly require adaptive sanitation systems (e.g. climate-proof infrastructure where there are sanitation-related contamination risks during floods or droughts, management systems that can trigger early warnings) | Howard G, Calow R, Macdonald A, Bartram J. Climate change and water and sanitation: likely impacts and emerging trends for action. Annu Rev Environ Resour. 2016;41:253–76. |
| | | | | (B) Evidence of multiple synergies, for example where resilient sanitation infrastructure blocks transmission paths; or where emptying systems are designed to limits risks of contamination during flood events | Sharpa AM, Kootleng T, Zuberbrog C, Cruse G. Vulnerability and adaptability of sanitation systems to climate change. J Water Clim Change. 2014;5:487–95. |
| | | | | (B) Evidence of multiple synergies, for example where resilient sanitation infrastructure blocks transmission paths; or where emptying systems are designed to limits risks of contamination during flood events | Kohlitz JP, Chong J, Wiltiffs J. Climate change vulnerability and resilience of water, sanitation, and hygiene services; a theoretical perspective. J Water Sanit Hyg Dev. 2017;7:181–95. |
| | | | | (C) Possible trade-offs where sanitation actions are no longer adapted to climate change impacts in the short- and/or long-term future | Bates N, Ross J, Calow R, Carter R, Doccia J. Adaptation to climate change in water, sanitation and hygiene services: assessing risks and appraising options in Africa. London: ODI; 2014. |
### Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---|---|---|---|---|---|
| 13.2 Integrate climate change measures into national policies, strategies and planning | 1 | 1 | 1 | (8) Multiple synergies where climate-related national measures lead to the strengthening of sanitation systems to increase resilience to impacts, or where changes made to sanitation systems lead to increased resilience to climate change. | - Oates N, Ross I, Calow R, Carter R, Doczi J. Adaptation to climate change in water, sanitation and hygiene: assessing risks and appraising options in Africa. London: ODI; 2014. |
| 13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning | 1 | 1 | 1 | (4) Target calls for action in sanitation sector to better mitigate, adapt to and reduce climate change and its impacts. | - Keim ME. Building Human resilience. Am J Prev Med. 2008;35:508–16. - Oates N, Ross I, Calow R, Carter R, Doczi J. Adaptation to climate change in water, sanitation and hygiene: assessing risks and appraising options in Africa. London: ODI; 2014. - Howard G, Calow R, Macdonald A, Bartram J. Climate change and water and sanitation: likely impacts and emerging trends for action. Annu Rev Environ Resour. 2016;41:253–76. - Fewster E. Resilient WASH systems in flood-prone areas; techniques to improve the resilience of community WASH systems in flood-prone areas. 2012. |
| 13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilising jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalise the Green Climate Fund through its capitalisation as soon as possible | 1 | 1 | 1 | (B) Synergies where mechanisms such as community participation or partnerships in developing countries enhance sanitation planning and management to adapt to climate change impacts. | - Sherpa AM, Koottatep T, Zurbrügg C, Cissé G. Vulnerability and adaptability of sanitation systems to climate change. J Water Clim Change. 2014;5:487–95. - Kohlitz JP, Chong J, Willetts J. Climate change vulnerability and resilience of water, sanitation, and hygiene services: a theoretical perspective. J Water Sanit Hyg Dev. 2017;7:181–95. - McNicol G, Jeliazovski J, François JJ, Kramer S, Ryals R. Climate change mitigation potential in sanitation via off-site composting of human waste. Nat Clim Change. 2020;10:545–9. |
| 14.1 Conserve and sustainably use the oceans, seas and marine resources for sustainable development | 1 | 1 | 1 | (4) Target requires action towards reduced marine pollution, including from unsafe waste disposal. (8) Evidence that safe treatment and disposal will reduce pollution. | - Baum R, Luh J, Bartram J. Sanitation: a global estimate of sewerage connections without treatment and the resulting impact on MDG progress. Environ Sci Technol. 2013;47:1994–2000. - Shuval H. Estimating the global burden of thalsasogenic diseases: human infectious diseases caused by wastewater pollution of the marine environment. J Water Health. 2003;1:53–64. |
Synergies and trade-offs between sanitation and the SDGs

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation identified? | C: Trade-offs between the target and sanitation identified? | Reasoning | Sample References |
|---------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|------------------------------------------------|
| 14.1 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans | 1 | 1 | 1 | (A) Target calls for action as sanitation systems need to be non-polluting (B) Research has looked into the link between sanitation and marine and coastal ecosystems, which can benefit from nutrient enrichment, or better protection from pollution if sanitation treatment/re-use/disposal is safe | - Aronson RB, Thatje S, McClinton JB, Hughes KA. Anthropogenic impacts on marine ecosystems in Antarctica. Ann N Y Acad Sci. 2011;1223:82–107. - Morris RM, Nunn BL, Fraser C, Goodlett DR, Ting YS, Rocap G. Comparative metaproteomics reveals ocean-scale shifts in microbial nutrient utilization and energy transduction. ISME J. 2010;4:673–85. |
| 14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans | 1 | 1 | 1 | (A) Target calls for action as sanitation systems need to be non-polluting (B) Research has looked into the link between sanitation and marine and coastal ecosystems, which can benefit from nutrient enrichment, or better protection from pollution if sanitation treatment/re-use/disposal is safe | - Aronson RB, Thatje S, McClinton JB, Hughes KA. Anthropogenic impacts on marine ecosystems in Antarctica. Ann N Y Acad Sci. 2011;1223:82–107. - Morris RM, Nunn BL, Fraser C, Goodlett DR, Ting YS, Rocap G. Comparative metaproteomics reveals ocean-scale shifts in microbial nutrient utilization and energy transduction. ISME J. 2010;4:673–85. |
| 14.3 Minimise and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels | 1 | 1 | 1 | (A) Target calls for action in the protection of coastal and marine areas that are affected by contaminated sewage effluents (B) Synergies as sustainable sanitation systems reduce marine pollution which reinforces the area-based conservation of marine areas | Same as for 14.1 |
| 14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics | 1 | 1 | 1 | (A) Target calls for action in the protection of coastal and marine areas that are affected by contaminated sewage effluents (B) Synergies as sustainable sanitation systems reduce marine pollution which reinforces the area-based conservation of marine areas | Same as for 14.1 |
| 14.5 By 2020, conserve at least 10% of coastal and marine areas, consistent with national and international law and based on the best available scientific information | 1 | 1 | 1 | Call for action in societies whose livelihood directly depends on wastewater aquaculture (B) Evidence that fisheries relying on wastewater can constitute a sustainable form of aquaculture and plays a part in poor populations’ livelihood | Bunting SW. Wastewater aquaculture: perpetuating vulnerability or opportunity to enhance poor livelihoods? World Poult Sci J. 2004;1:51–75. - Kumar B, Kumar KS, Priya M, Mukhopadhyay D, Shah R. Distribution, partitioning, bioaccumulation of trace elements in water, sediment and fish from sewage fed fish ponds in eastern Kolkata, India. Toxicol Environ Chem. 2010;92:243–60. - Edwards PEt. Reuse of human wastes in aquaculture: a technical review [Online]. Washington DC; 1992. |
## Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---|---|---|---|---|---|
| 14.a | Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular Small Island Developing States and least developed countries | 1 | 1 | (B) Synergies identified, for example, where evidence for this? | - Nichols PD, Leeming R, Rayner MS, Latham V. Use of capillary gas chromatography for measuring fecal-derived steroids: application to stormwater, the sea-surface microlayer, beach greases, regional studies, and distinguishing algal blooms and human and non-human sources of sewage pollution. J Chromatogr A. 1996;733:497–509. |
| 14.b | Provide access for small-scale artisanal fishers to marine resources and markets | 1 | 1 | (B) Synergies identified, for example, where evidence for this? | - Sajithini S, Naile PA, Leusch FDL. Wastewater treatment plant effluent as a source of microplastics: review of the fate, chemical interactions and potential risks to aquatic organisms. Water Sci Technol. 2016;74:2253–69. |
| 14.c | Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 156 of The Future We Want | 1 | 1 | (B) Synergies identified, for example, where evidence for this? | - Kimball LA. International Ocean Governance: using international law and organizations to manage marine resources sustainably. Revised ed. iUCN – The World Conservation Union. Gland: International Union for Conservation of Nature and Natural Resources (IUCN); 2003. |

| Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss | | | | | |
|---|---|---|---|---|---|
| 15.1 | By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements | 1 | 1 | (A) Target requires conservation of ecosystems which includes pollution reduction and safe disposal of human waste for both ecological purposes | - UN-Water. Towards a worldwide assessment of freshwater quality: a UN-water analytical brief. UN-Water Analytical Brief. Geneva 2016. |
| 15.2 | By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally | 1 | 1 | (B) Multiple synergies, for example where evidence for this? | - Simha P, Ganesapillai M. Ecological sanitation and nutrient recovery from human urine: how far have we come? a review. Sustain Environ. Res. 2017;27:107–16. |

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Sample References:
- J Chromatogr A. 1996;733:497–509.
- Water Sci Technol. 2016;74:2253–69.
- Kimball LA. International Ocean Governance: using international law and organizations to manage marine resources sustainably. Revised ed. iUCN – The World Conservation Union. Gland: International Union for Conservation of Nature and Natural Resources (IUCN); 2003.
- UN-Water. Towards a worldwide assessment of freshwater quality: a UN-water analytical brief. UN-Water Analytical Brief. Geneva 2016.
- Simha P, Ganesapillai M. Ecological sanitation and nutrient recovery from human urine: how far have we come? a review. Sustain Environ. Res. 2017;27:107–16.
- Thevenon F. Sustainable sanitation systems: health, environment and governance challenges. Geneva: WaterLex; 2017.
- Metcalfe CD, Nagabhatla N, Fitzgerald SK. Multifunctional wetlands: pollution abatement by natural and constructed wetlands. In: Multifunctional Wetlands. Cham: Springer; 2018. p. 1–14.
- Koottatep T, Suninkul N, Polprasert C, Kamal ASM, Kone D, Montangero A, et al. Treatment of septage in constructed wetlands in tropical climate: lessons learnt from seven years of operation. Water Sci Technol. 2005;9:119–26.
- Jordan MJ, Nadelhoffer KJ, Fry B. Nitrogen cycling in forest and grass ecosystems irrigated with 15N-enriched wastewater. Ecol Appl. 1997;7:864-81.
- Bramryd T. Impact of sewage sludge application on the long-term nutrient balance in acid soils of Scots pine (Pinus Sylvestris, L.) forests. Water Air Soil Polut. 2002;140:381–99.
- Bramryd T. Long-term effects of sewage sludge application on the heavy metal concentrations in acid pine (Pinus sylvestris L.) forests in a climatic gradient in Sweden. For Ecol Manage. 2013;289:434–44.
### Goal or Target in the 2030 Agenda for Sustainable Development

| A | Does the target require certain actions in relation to sanitation systems? | B | Synergies between the target and sanitation systems? | C | Trade-offs between the target and sanitation systems? | Reasoning |
|---|---|---|---|---|---|---|
| 15.3 | By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world. | 1 | 1 | 1 | | (B) Synergies, for example, where treated urine is re-used to irrigate plant cover to harnessing deserts and preventing desertification. (C) Evidence of natural habitats and biodiversity enhanced with re-use of faeces. |
| 15.4 | By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development. | 1 | 1 | 1 | | (B) Synergies, for example, where safe disposal of waste reduces pollution on mountain ecosystems or helps enhancing them. (C) Evidence of natural habitats and biodiversity enhanced with re-use of faeces. |
| 15.5 | Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species. | 1 | 1 | 1 | | (B) Synergies may occur where sustainable sanitation systems reduce pollution and reinforce ecosystem equilibrium for native plant species to thrive. (C) Trade-offs could occur as non-native species may be introduced with certain types of sanitation systems. |
| 15.6 | Promote the use of environmentally sound technologies and promote sustainable practices in all areas of human activity, in order to achieve the sustainable use of natural resources. | 1 | 1 | 1 | | (B) Synergies include planning strategies that integrate ecosystem and biodiversity development through re-use and safe disposal of human waste. |

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## Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---------------------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|--------------------------------------------------|
| 15.a Mobilise and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems | 1 | 1 | (B) Synergies include financial investment in the conservation and sustainable use of ecosystems through re-use of and safe disposal of human waste | Werner C, Panesar A, Rüd SB, Ott CU. Ecological sanitation: principles, technologies and project examples for sustainable wastewater and excreta management. Desalination. 2009;248:392–401. | |
| 15.b Mobilise significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation | 1 | 1 | (B) Synergies as per Target 15.2 | | |
| 15.c Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities | | | | | |

### Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

| 16.1 Significantly reduce all forms of violence and related death rates everywhere | 1 | 1 | (A) Target calls for action in sanitation, including where facilities are places of violence | Corburn J, Hildebrand C. Slum sanitation and the social determinants of women’s health in Nairobi, Kenya. J Environ Public Health. 2015;2015:1–6. | |
| 16.2 End abuse, exploitation, trafficking and all forms of violence against and torture of children | | | | | |
| 16.3 Promote the rule of law at the national and international levels and ensure equal access to justice for all | | | | | |
| 16.4 By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organised crime | | | | | |
| 16.5 Substantially reduce corruption and bribery in all their forms | 1 | 1 | (A) Target calls for action in sanitation, for example, where corruption impacts access to sanitation | Jenkins M. The impact of corruption on access to safe water and sanitation for people living in poverty. Anti-Corruption Res Cent. 2017;6. | |
| 16.6 Develop effective, accountable and transparent institutions at all levels | 1 | 1 | (A) Target calls for action to increase accountability to create inclusive decision-making in sanitation | Kennedy-Walker R, Amara FM, Paterson CA. The rate of power, politics and history in achieving sanitation service provision in informal urban environments: a case study of Lusaka, Zambia. Environ Urban. 2015;27:489–504. | |
### Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|---------------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------------|---------------------------------------------|------------------------------------------------|--------------------------------------------------|
| **16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels** | 1 | 1 | 1 | (A) Target calls for action to increase accountability to create inclusive decision-making in sanitation | - Seppälä OT. Effective water and sanitation policy reform implementation: need for systemic approach and stakeholder participation. Water Policy. 2002;4:367–76. - Khan S. Swachh Bharat Mission (urban): needs vs planning. New Delhi: Centre for Policy Research; 2018. |
| **16.8 Broaden and strengthen the participation of developing countries in the institutions of global governance** | 1 | 1 | 1 | (B) Multiple synergies including in the pursuit of justice for all which involves access to sanitation by all | - Miletzki J, Broten N. Development as freedom. London: Macat International; 2017. |
| **16.9 By 2030, provide legal identity for all, including birth registration** | - | - | - | (C) But also trade-offs if taxes add burden on households which are prevented from investing in sanitation; or where national revenues from taxes do not go into sanitation | - Cha S, Mankadi PM, Bhag MS, Lee Y, Jin Y. Trends of improved water and sanitation coverage around the globe between 1990 and 2010: inequality among countries and performance of official development assistance. Glob Health Action. 2017;10:1327170. - Newborne P, Tucker J, Bayliss K. Strengthening pro-poor targeting of investments by African utilities in urban water and sanitation – the role of the International Development Association of the World Bank. London: Water Aid; 2012. |
| **16.a Strengthen relevant national institutions, including through international cooperation, for building capacity at all levels, in particular in developing countries, to prevent violence and combat terrorism and crime** | 1 | 1 | 1 | (A) Call for action to ensure inclusive laws and policies in relation to sanitation | - House S, Fieron S, Cavill S. Scoping and diagnosis of the global sanitation fund’s approach to Equality and Non-Discrimination (EQND). GSF and WSSCC; 2017. |
| **16.b Promote and enforce non-discriminatory laws and policies for sustainable development** | 1 | 1 | 1 | (B) Evidence that improved domestic resource mobilisation can improve sanitation systems; and that sanitation systems may support tax and revenue collection at national level particularly where willingness to pay for such services is high | - Bisaga I, Norman G, Drabble S. How can we influence municipal governments to allocate more money to sanitation? London: Water & Sanitation for the Urban Poor; 2015. - UNICEF. Water and sanitation budget brief. UNICEF; 2016. |
| **17 Strengthen the means of implementation and revitalise the global partnership for sustainable development** | | | | | |
| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|-------------------------------------------------------------|-------------------------------|-------------------------------------|-------------------------------------|-------------|-------------------------------|
| 17.3 Mobilise additional financial resources for developing countries from multiple sources | 1 | 1 | (B) Synergies where blended finance strengthens sanitation systems | - OECD. Meeting the challenge of financing water and sanitation. Paris: OECD; 2011. |
| 17.4 Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress | 1 | 1 | (B) Synergies where policies foster debt financing, relief and/or restructuring and enable investment in sanitation (C) Potential trade-offs where debt still poses major barriers to the sanitation sector or where sanitation increases accumulation of further debts | - Newborne P, Tucker J, Bajriss K. Strengthening pro-poor targeting of investments by African utilities in urban water and sanitation – the role of the International Development Association of the World Bank. London: WaterAid; 2012. |
| 17.5 Adopt and implement investment promotion regimes for least developed countries | 1 | 1 | (B) Synergies where such investment promotion regimes benefit the sanitation sector | - Goksu A, Trémollet S, Kolker J, Kingdom B. Easing the transition to commercial finance for sustainable water and sanitation. Washington D.C: The World Bank; 2017. |
| 17.6 Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism | 1 | 1 | (B) Multiple synergies exist as a result of international co-operation and knowledge sharing leading to increased sanitation access | - Gopalan S, Rajan RS. Has Foreign aid been effective in the water supply and sanitation sector? Evidence from panel data. World Dev. 2016;85:84–104. |
| 17.7 Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed | 1 | 1 | (B) Synergies as per Target 17.6 | - Khan S. Swachh Bharat Mission (Urban): needs vs planning. New Delhi: Centre for Policy Research; 2018. |
| 17.8 Fully operationalise the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology | 1 | 1 | (B) Synergies as per Target 17.6 | - Górecki H, Mwenga M, Ndeze T. Local empowerment through community mapping for water and sanitation in Dar es Salaam. Environ Urban. 2004;16:185–98. - McGranahan G, Walnycki A, Dominick F, Willard K, Kyessi A, Mtwangi Limbumba T, et al. Universalizing water and sanitation coverage in urban areas: from global targets to local realities in Dar es Salaam, and back. London: IIED; 2016. |
Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|-------------------------------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| 17.9 Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the sustainable development goals, including through North-South, South-South and triangular cooperation. | 1 | (B) Synergies as per Target 17.6 | - As per Target 17.6 | - UN Environment. Progress on integrated water resources management. Global Baseline for SDG 6 Indicator 6.5.1: degree of IWRM Implementation. 2018. - Newborne P, Ranaivoari A, Rabeantoandro F. Sanitation and hygiene in developing countries: identifying and responding to barriers. 2007. |
| 17.10 Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organization, including through the conclusion of negotiations under its Doha Development Agenda | 1 | Is there evidence for this? | (B) Synergies where this coincides with the sustainable development of sanitation systems | - Newborne P, Ranaivoari A, Rabeantoandro F. Sanitation and hygiene in developing countries: identifying and responding to barriers. 2007. |
| 17.11 Significantly increase the exports of developing countries, in particular with a view to doubling the least developed countries' share of global exports by 2020 | 1 | Is there evidence for this? | (B) Synergies where these policies for sustainable development (as per Target 17.14) and poverty eradication are associated to investments in adequate, equitable and dignified sanitation | - OECD. Partnerships to enhance policy coherence for sustainable development. In: Policy Coherence For Sustainable Development 2017: eradicating poverty and promoting prosperity. Paris: OECD Publishing; 2017. - Newborne P, Ranaivoari A, Rabeantoandro F. Sanitation and hygiene in developing countries: identifying and responding to barriers. 2007. |
### Appendix. Continued

| Goal or Target in the 2030 Agenda for Sustainable Development | A: Does the target require certain actions in relation to sanitation systems? | B: Synergies between the target and sanitation | C: Trade-offs between the target and sanitation | Reasoning | Sample References |
|-------------------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| 17.16 Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the sustainable development goals in all countries, in particular developing countries | 1 | 1 | 1 | (B) Multiple synergies as multi-stakeholder partnerships can help foster better access to sanitation | ODI, FDC. Multi-Stakeholder Partnerships Issue Paper Pulling together to uplift and empower the world. Kuala Lumpur: GKP; 2003. Murphy HM, McBean EA, Farshad Khan K. Appropriate technology – a comprehensive approach for water and sanitation in the developing world. Technol Soc. 2009:31:158–67. |
| 17.17 Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships | 1 | 1 | 1 | (B) Synergies as per Target 17.16 | Allen A, Hofmann P, Mukherjee J, Walnycki A. Water trajectories through non-networked infrastructure: insights from peri-urban Dar es Salaam, Cochabamba and Kolkata. Urban Res Pract. 2017;10:22–42. |
| 17.18 By 2030, enhance capacity-building support to developing countries, including for least developed countries and Small Island Developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts | 1 | 1 | 1 | (B) Multiple synergies, for example, where capacity-building to developing countries through or trainings in the sanitation sector lead to improved access to sanitation | McGranahan G, Walnycki A, Dominick F, Willard K, Kyessi A, Mtwangi Limbumba T, et al. Universalising water and sanitation coverage in urban areas: from global targets to local realities in Dar es Salaam, and back. London: iiED; 2016. Cotton A, Bartram J. Sanitation: On- or off-track? issues of monitoring sanitation and the role of the joint monitoring programme. Waterlines. 2008:27:12–29. |
| 17.19 By 2030, build on existing initiatives to develop measurement of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries | 1 | 1 | 1 | (B) Multiple synergies that include capacity-building leading to progress tracking and action-taking from strong Monitoring and Evaluation (M&E) processes, and supporting the identification of gaps where action in sanitation is needed | Cotton A, Bartram J. Sanitation: On- or off-track? Issues of monitoring sanitation and the role of the joint monitoring programme. Waterlines. 2008:27:12–29. |

| COUNT | 83 | 131 | 130 | 29 | 28 |
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Declarations and conflict of interest

The authors declare no conflicts of interest in connection to this article.

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Author contributions

P.P. led the study team, contributed to the development of the initial and adapted methodology and paper search exercise and data analysis and led the writing of the manuscript. L.D. led the evidence based paper search exercise and contributed to the development of the adapted methodology, data analysis, data capture and writing. J.T. and Y.M. contributed to the development of initial and adapted methodology, paper search exercise, data analysis and writing. B.M. contributed to the development of the initial methodology, paper search exercise, data analysis and writing. T.T. and M.L. contributed to the development of the adapted methodology, paper search exercise, data analysis and writing. All authors helped to critique the output for intellectual content.

Open data and materials availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Note

1 Workshop organised at the Vitol Foundation in September 2019.

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