World Development Sustainability 2 (2023) 100038

Contents lists available at ScienceDirect

World Development Sustainability

journal homepage: www.elsevier.com/locate/wds

Localisation of links between sanitation and the Sustainable Development Goals to inform municipal policy in eThekwini Municipality, South Africa

Lucila Carbonell[a], Pascale Hofmann[a], Nevana Srikissoon[b], Luiza C. Campos[c], Sandile Mbatha[d], Monica Lakhanpaul[e], Vishnu Mabeer[f], Ine Steenmans[g], Priti Parikh[h,*]

[a] The Bartlett Development Planning Unit, UCL, 34 Tavistock Square, London WC1H 9EZ, UK
[b] eThekwini Municipality Performance, Monitoring and Evaluation Unit, 6th Floor, 41 Margaret Mncadi Avenue, Durban, 4001, South Africa
[c] Department of Civil, Environmental and Geomatic Engineering, UCL, Gower St., London WC1E 6BT, UK
[d] eThekwini Municipality Office of Strategic Management, 15th Floor, Nedbank Building; Durban, 4001, South Africa
[e] UCL Great Ormond Street Institute of Child Health, 30 Guildford Street, London WC1N 1EH, UK
[f] eThekwini Municipality Water and Sanitation Service Unit, 2nd Floor, 3 Prior Road, Durban, 4001, South Africa
[g] UCL Department for Science, Technology, Engineering and Public Policy, London, UK
[h] Bartlett School of Sustainable Construction, UCL, London, UK

ARTICLE INFO

Keywords:
SDGs
eThekwini
Sanitation
Sustainable development goals
Synergies
Risk
Interlinkages
Trade-offs

ABSTRACT

Significant strides have been made in eThekwini Municipality, Durban, towards achieving Sustainable Development Goal 6 (SDG6) but with 27% of households lacking access to basic sanitation in 2020, challenges remain. While there is global evidence of sanitation linking to all 17 SDGs, similar localised linkages between sanitation and the SDGs in the context of Durban have not yet been verified. Evidencing these linkages and related co-benefits across SDGs could galvanise efforts towards mutually achieving SDG6 and other SDGs by highlighting potential funding efficiencies across multiple benefiting sectors and providing data for longer-term cross-departmental collaboration.

This study bridges a persistent gap between research and policy through a collaborative process facilitating the localisation of links between sanitation and SDGs to aid reporting needs and optimise resource use based on evidence of multiple benefits across SDGs. A structured evidence appraisal process identifies linkages between sanitation and all 17 SDGs, including 83 synergies, 49 risks and 4 trade-offs.

Our review reveals that lack of adequate sanitation in public spaces has implications for poverty, inequality, informality and dignity. Despite supportive policies, there is a need to enhance participation in decision-making to develop more appropriate sanitation solutions and enhance community acceptance. Findings demonstrate how local policies on sanitation contribute to reducing inequality and poverty but to achieve synergistic outcomes requires addressing existing risk, e.g. in relation to differentiated provision of sanitation solutions or policies that are not always well targeted.

There are further opportunities in eThekwini to promote circularity through wastewater reuse and using faecal sludge for energy and fertilizer production. A key consideration for eThekwini's Water and Sanitation unit is to avoid negative environmental impacts whilst developing solutions for areas that lack infrastructure. The research also identified data gaps, particularly between sanitation interventions and climate action and sanitation data for vulnerable groups.

* Corresponding author at: Engineering for International Development Centre, Bartlett School of Sustainable Construction, The Bartlett, UCL Faculty of the Built Environment, 2nd Floor 1-19 Torrington Place London, WC1E 7HB

E-mail addresses: lucila.carbonell.14@ucl.ac.uk (L. Carbonell), p.hofmann@ucl.ac.uk (P. Hofmann), nevana.srikissoon@durban.gov.za (N. Srikissoon), l.campos@ucl.ac.uk (L.C. Campos), sandile.mbatha2@durban.gov.za (S. Mbatha), m.lakhanpaul@ucl.ac.uk (M. Lakhanpaul), vishnu.mabeer@durban.gov.za (V. Mabeer), ine.steenmans@ucl.ac.uk (I. Steenmans), priti.parikh@ucl.ac.uk (P. Parikh).

https://doi.org/10.1016/j.wds.2022.100038
Received 14 March 2022; Received in revised form 12 November 2022; Accepted 12 December 2022

1. Introduction: sanitation in eThekwini and the SDGs

1.1. Progress in advancing sanitation provision in eThekwini

Sanitation is a human right and a basic need with wide reaching implications for dignity and quality of life, yet universal sanitation access is unlikely to be met by 2030. Goal 6 of the Sustainable Development Goals (SDGs) aims to "by 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations" [1]. However, almost two billion people worldwide lack access to basic sanitation[1] and more than 673 million still practice open defecation [1,2].

In 2019, only 34% of the African population had access to at least limited sanitation services[2] [3]. In South Africa, universal access to sanitation is not only a key SDG but also entrenched in the constitution and the National Sanitation Policy of 2016. While access to basic sanitation has increased nationally from 61.7% in 2002 to 82.1% in 2019, a significant gap remains [4,5]. In eThekwini Municipality, 73% of households had access to a basic level of sanitation in 2020 [6] with challenges regarding the maintenance of existing infrastructure as well as extending sanitation provision to less accessible areas, requiring new approaches to continue moving forward. eThekwini is the largest city in the South African province of KwaZulu-Natal, with a population of 3.9 million people and an area of 2,297 square km[3], encompassing a large rural periphery with informal settlements and challenging topography [7]. The city has high levels of poverty and inequality with low economic diversity and rapid urbanisation. eThekwini has become a pioneer in providing access to water and sanitation to its residents based on the belief that it is morally responsible and financially wise. In fact, eThekwini Water and Sanitation (EWS) was the first Water Service Authority in South Africa to provide free basic water to the poor in 2000 before the National Free Basic Water policy in 2001 [9,11,12]. In line with the city's constitutional mandate, EWS strives to provide water and sanitation services that are equitable; affordable; efficient and effective; sustainable; and professional [6] and was recognised as one of the most progressive utilities through the Stockholm Industry Water Award in 2014 [13]. However, the legacy of spatial segregation and inequality from apartheid continues to pose challenges for eThekwini Municipality in providing universal sanitation access. EWS has developed a spatially differentiated discourse around sanitation provision resulting in disparate access due to distinct sanitation solutions for specific areas of the city. According to Sutherland and Bonang (2012), this approach is underpinned by past and present socio-economic and environmental factors, including underdevelopment of previously disenfranchised townships and rural areas during apartheid; steep topography; lack of planning and investment for bulk infrastructure; high cost of providing services in highly dispersed and peripheral areas; the limitation of waterborne sewerage on the urban boundary; and significant environmental constraints.

Sanitation in rural areas consists of state provided Ventilated Improved Latrines (VIP), which are de-sludged by the city; Urine Diversion Toilets (UDT), or dry sanitation toilets; and self-built traditional pit latrines. Formal urban areas are connected to waterborne sanitation using flush systems. Informal settlements within the urban boundary are serviced by means of Community Ablution Blocks (CAB's) [4] as an 'interim' solution while informal households outside the urban boundary are provided with UDTs. However, EWS stopped building CABs as their operation and maintenance has become too costly. At the same time, there is a need to challenge an aspiration toward flush-based toilet systems requiring large quantities of water. There is scope for decentralised onsite sanitation systems outside the waterborne boundary that can generate value from the waste.

The Municipality continues to struggle with generating sufficient revenue from water supply and sanitation services and allocating sufficient funds to maintenance. Services for the large percentage of indigent households are not revenue generating. In 2020, eThekwini Municipality classified 768,258 households as indigent (18% of the national total) [8–10], which comprises those "lacking the necessities of life such as, but not necessarily limited to, sufficient water, basic sanitation, refuse removal, housing and/or a supply of basic electricity" and unable to make monetary contributions to basic services due to financial hardships [15]. Approximately 30% of land in KwaZulu-Natal is held by the Ingonyama Trust Board – a board formed to administer customary land owned by Zulu people [14]. While the properties on this land are provided with services such as water and sanitation, the owners are not billed as the land is not included in the Municipal valuation roll. Land ownership challenges and rapid urbanisation put a further strain on existing infrastructure while also increasing the need for services. Settlements in more remote, uneven terrain are particularly hard to reach and more expensive to service.

As the spatially differentiated approach adopted by the municipality has failed to address existing inequality and injustices, academics at University of KwaZulu-Natal (UKZN) advocate for inclusive and equitable service provision [12]. The authors argue that the approach leads to differential citizenship characterised by a class or 'lifestyle' apartheid (rather than race-based) and non-inclusive development risking further marginalising disadvantaged groups and aggravating their conditions [9].

1.2. Sanitation and the SDGs

The SDGs are increasingly seen as interacting components, with research examining intersections and linkages between SDGs at different scales, with evidence of sanitation linking to multiple SDGs [16,17]. A global evidence review identified linkages between sanitation and all 17 SDGs and 130 SDG Targets. Another study revealed links between sanitation, wastewater treatment and 15 SDGs [18]. However, to support cross-sectoral investment and activities at the local level requires context-specific evidence of such links. In South Africa, the Water Research Commission (WRC) commissioned a report on mapping water and sanitation interlinkages across the SDGs at the national level but lacks a localised evidence base [19]. According to Allen et al. [20], (2021) data to monitor and implement the SDGs is limited, particularly for environment-related SDG interactions. Fox and Macleod [21] recognise the need for inter-sectoral collaboration to tackle persistent siloes in local government that hinder collective efforts to meet the SDGs.

Cities adapting, global policies such as the SDGs and translating and implementing in the local context is a necessary step towards achieving the SDGs. While some cities have been working on this, e.g. through Voluntary Local Reviews (VLRs) to localise SDG implementation, the number of municipalities able to pursue this consistently remains limited [21–24]. In eThekwini, work on SDG localisation is ongoing but requires good quality data at the city level to formulate policies and address local challenges [25]. Identifying and evidencing linkages between sanitation and SDGs in the context of Durban makes a valuable

[1] According to the Joint Monitoring Programme (JMP) of WHO and UNICEF, this refers to the proportion of the population using an improved sanitation facility (including flush/pour flush to piped sewerage systems, septic tanks or pit latrines; ventilated improved pit latrines; composting toilets or pit latrines with slabs). access.

[2] This refers to access to improved sanitation facilities that are shared with other households.

[3] As a result of redrawing the municipal boundary in 2000, it increased by 67 per cent compared to the previous Durban Metropolitan Area (Sutherland et al., 2015, p. 491).

[4] The CABs include a male and a female section with toilets, handwashing basin, wash basin to clean clothes and showers as well as urinals in the male side. Not all CABs are well received by the community.

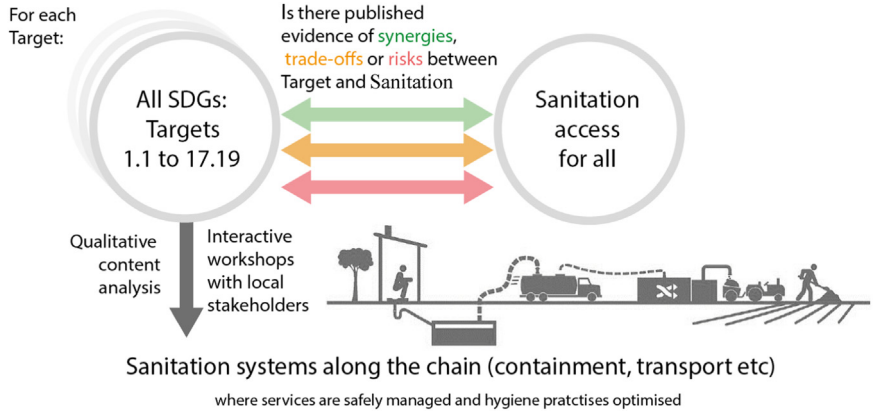

Fig. 1. Methodology to assess the interlinkages between sanitation systems and the SDGs (adapted from Fuso Nerini et al., 2018).

contribution to the localisation of SDGs and plays an important role in the mobilisation and use of resources toward wide ranging benefits. Sanitation provision that "leaves no one behind" further requires a collaborative effort from stakeholders across sectors.

1.3. Localisation of SDGs in eThekwini Municipality

eThekwini Municipality aims to innovate and support the process of localisation and implementation of SDGs in the Global South. The Municipality has aligned its capital budget expenditure to the SDGs and has largely integrated the SDGs into city development planning [26]. Its SDG Institutionalization Committee comprises members from multiple Municipal departments to localise, rationalise and contextualise SDG targets, engage with stakeholders and develop a monitoring tool with localised indicators to track progress of the implementation of SDGs and sustainability. It is in this context that a collaboration with a team of interdisciplinary academics from University College London (UCL) emerged to explore the synergies, trade-offs and risks associated with the provision of sanitation in Durban.

2. Methods

2.1. Definition of sanitation

The paper adopted the definition of sanitation developed by Parikh et al. [27] based on SDG6 aimed at achieving access to adequate, equitable and dignifying sanitation and hygiene for all, paying attention to facilities and safely managed services for the safe handling and disposal of human urine and faeces along the sanitation chain (see Box 1).

Box 1. Definition of sanitation [27]

> 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

This builds upon the WHO definition that emphasises the separation of human excreta from human contact at all steps of the sanitation service chain and calls for consistency with human rights (2018, p. 5), and further pays attention to social diversity and inclusivity (stressing particularly the needs of women and children) as well as capacity-building of local communities. Durban's definition of sanitation is similar, however also includes consideration for the balance between affordability and appropriateness of the sanitation system; as well as the system's impact on the environment [28].

2.2. Building upon an established methodology

This research builds on a methodology initially developed by researchers from UCL to identify linkages between energy and the SDGs [29]. It consisted of an evidence review to identify linkages with SDGs and targets through a structured process, producing a graphic summary of the analysis (wheel diagrams) and a matrix with the evidence identified. A UCL team adopted this methodology to identify linkages between sanitation and all 17 SDGs at a global scale by reviewing over 500 publications (global mapping) [27], followed by similar work applying the methodology to Brazil [30]. This paper continues the line of research and responds to a need for a contextualised exploration of linkages between sanitation and the SDGs, as identified in the global mapping, in eThekwini Municipality in Durban, South Africa.

The team reviewed over 100 documents that referred to Durban or South Africa . These include academic publications; grey literature such as reports from NGOs; local and national policies; internal reports; reports by experts; research studies; masters and PhD theses; and newspaper and magazine articles. This was complemented by the expertise of participating stakeholders on particular issues that led to the identification of further linkages and evidence substantiated through newspaper articles. The links were not weighted or quantified as the aim was to showcase all direct and indirect links between sanitation and the SDGs.

The Durban evidence review identified three types of linkages between sanitation and all SDG targets[5]: synergies, trade-offs and risks as shown in Fig. 1. Synergies refer to "two-way positive connections with sanitation for each target, that is, whether action in sanitation could support the achievement of the target and if achievement towards the target could support sanitation objectives" and trade-offs refer to two-way negative connections with sanitation for each target [30]. Multiple synergies were identified, demonstrating the benefit of a specific sanitation solution. However, the team further identified (potential) risks to inhabitants and the broader environment associated with the ways in which sanitation infrastructure and services are provided.

[5] The global mapping also included calls for action: a category looking at whether the achievement of a specific target required action in sanitation. This project did not include calls for action as this was already established through the global mapping and is not expected to change across contexts.

Risks constitute a new and important addition to the methodology and are distinct from trade-offs, which occur even if a sanitation system is totally safe. For example, having sanitation in schools was identified as a synergy with SDG 4 on quality education [31]. However, literature also highlighted risks regarding sanitation systems in schools that cannot be easily seen and monitored by school staff as they can enable violence or drug use [32,33]. Similarly, toilets that are not clean, accessible, maintained and with adequate facilities for menstrual hygiene can lead to increased absenteeism and negatively impact on girls' education [34]. The mapping of risks constitutes an important addition to the original methodology when applied in a specific context as it identifies the impact of inadequate sanitation systems. This means that Municipality officials and other stakeholders need to address the risks identified to enhance sanitation solutions at the local level.

2.3. Interdisciplinary collaboration

The project team was comprised of academics and practitioners from UCL and eThekwini Municipality, respectively, with expertise in engineering, social science, urban development planning, health, policy and architecture. Local governments in particular play a crucial role in implementing the SDGs to avoid some of the failures regarding the Millennium Development Goals (MDGs) where aggregate data hid inequalities at the local level, specifically lack of progress among the poorest groups (Fox and Macleod (2021). Accordingly, collaboration between academics and eThekwini Municipality leveraged the city's strategic focus to localise SDGs. The team met fortnightly online to review evidence on linkages and co-develop project outputs. This was complemented by three online consultations with a broader group of stakeholders from eThekwini Municipality and beyond, including members of the SDG Institutionalisation Committee, Umgeni Water, the Water Research Commission, UKZN, Stats SA, the Council for Scientific and Industrial Research as well as the City of Los Angeles. Consultation meetings were facilitated using interactive tools.

As argued by Immler and Sakkers (2021) involvement of local stakeholders is key to translate (rather than simply implement) the SDGs to the local level. The collaborative approach adopted enabled the process of SDG localisation to be grounded in the local context and building on local knowledge and partnerships. Working collaboratively allowed inputs from cross-sectoral actors, fostered conversations across fields to better understand linkages and helped to identify local evidence detailing issues around sanitation typically excluded from academic outputs such as internal municipal documents and newspaper articles.

2.4. Matrix and visual outputs

The linkages identified and documented are available in Appendix 1: Matrix, which makes the research traceable and enables further sources to be added in future. Data gaps for the Durban context (where the team was unable to find local evidence for linkages identified in the global mapping) need to be explored in the future and are discussed further in the findings. The outputs produced include three graphic summary results of the analysis (wheel diagrams) and three node mappings which are another addition to the methodology. The node mapping demonstrates the complex interrelationships among targets for three selected SDGs - SDG 5 on gender; SDG 11 on sustainable cities and communities and SDG 13 on climate action – which were considered most relevant for the city in relation to the literature sources and the initial findings.

2.5. Limitations

The diverse range of evidence used to allow the team to consider all targets across SDGs limits the consistency of the data in terms of its scientific origin. For example, an academic research study based on a long and systematic investigation is different from a three-page report from an institution such as the World Bank with a purpose to showcase impactful investment. Similarly, a policy at national level to guide government officials differs from a newspaper article. The team dealt with the unevenness in the evidence base through dialogue, a reflexive process and consensus and decided collectively what to include and why whilst classifying the type of evidence identified. While the links identified between sanitation and SDGs enables eThekwini Municipality to take informed decisions on sanitation services based on risks and trade-offs, the current study did not consider costings of various options. This should be part of a future study to enable the Municipality to fundraise for service delivery.

3. Results and discussion

This research identified linkages between sanitation and all 17 SDGs, including 83 synergies, 49 risks and 4 trade-offs, with further interlinkages across targets. The results are presented at two levels. Firstly, through three wheel diagrams that summarise the results and represent the number of linkages between sanitation and all SDG targets. Secondly, through node mappings for three selected SDGs that explore in detail how linkages between each goal's targets and sanitation further connect with other SDG targets.

3.1. Wheel diagrams - synergies

The research identified multiple synergies between sanitation and poverty (SDG1), health (SDG3), affordable and clean energy (SDG7), industry innovation and infrastructure (SDG9), sustainable cities and communities (SDG11) and partnerships for the goals (SDG17) (Fig. 2). Fewer synergies emerged for decent work and economic growth (SDG8), reduced inequalities (SDG10), life below water (SDG14), life on land (SDG15), and peace, justice and strong institutions (SDG16). This is not surprising, particularly when focusing on a city context. Moreover, the number of links within each SDG is not necessarily a reflection of

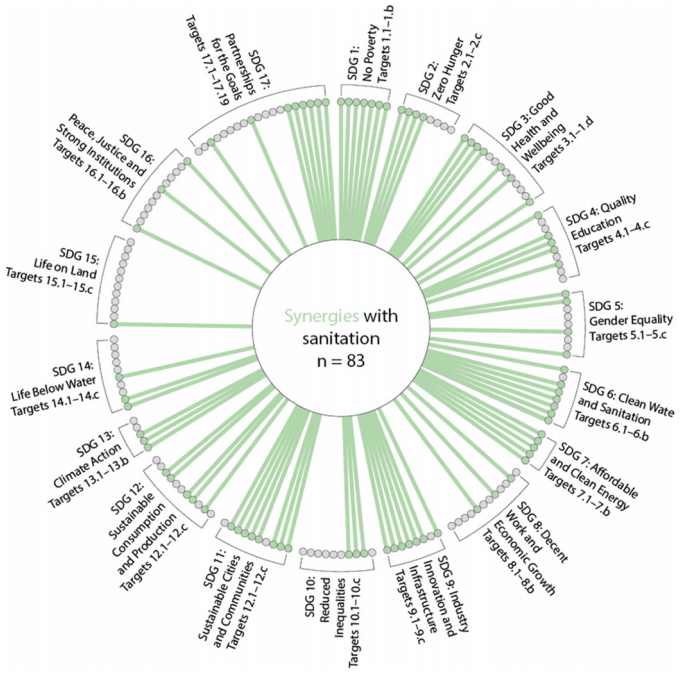

Fig. 2. Synergies between sanitation and SDGs in Durban (Based on the approach of Parikh et al. [27]).

the strength of linkages but rather indicates the wide-ranging links and potential benefits that can be leveraged through sanitation interventions.

The eThekwini Indigent Policy 2020-21 and the eThekwini Sanitation Policy provide a framework for the provision of a social package of benefits addressing poverty and inequality through a free basic sanitation service [15,28]. Similarly, the Municipal Infrastructure Grant subsidised the installation of basic services, including water and sanitation. These policies have further synergies between sanitation and health as they also cover the cost of hygiene promotion with households [35]. Other health-related synergies include links between improved sanitation and reduced maternal mortality; reduced incidence of diarrhoea; a decrease in waterborne diseases and better mental health [36–42]. These synergies corroborate the findings from the global mapping and highlight an opportunity for local policies to enhance public health through improved access to sanitation [27].

The provision of private, secure sanitation and active engagement with community members including women are key synergies between sanitation and peace, justice and strong institutions as well as education and gender equality. A study by Gibbs and Reddy (2020) highlights the need to consider the prevention of social violence when improving access to private and secure sanitation facilities. This is particularly important in schools and informal settlements; adequate sanitation is one of the contributing factors to reducing violence such as bullying in schools, and sanitation facilities located closer to home, particularly in informal settlements where shared facilities are common, increase safety for women [33,43,44]. Adequate sanitation in schools is also linked to reduced absenteeism and enabling equal learning opportunities for girls and boys [31,32,34]. The municipality's engagement with community members such as local traders, or dwellers in informal settlements in the improvement of sanitation in public spaces leads to better outcomes and improved relationships [45–47]. These findings show that the number of facilities is important, but it is equally vital to include diverse voices in decisions around the location, design, and maintenance of facilities to ensure inclusive and sustained access.

Multiple synergies were identified around the treatment of wastewater, for example between sanitation and industry, innovation and infrastructure related to wastewater recycling for reuse within industry; alternative wastewater treatment options and financial opportunities from development banks for recycling wastewater (Bill & Melinda Gates Foundation, n.d.; Department of Water and Sanitation, 2018; Jacobsen et al., 2012). Rethinking treatment of wastewater provides an opportunity for circularity and resource efficiency to take centre stage in sanitation systems in Durban. Examples include the production of dry pellets from sludge [50–52] and using wastewater as a resource for energy generation, production of biogas and improved energy efficiency in wastewater treatment [48,53–55]. The study further identified synergies with sustainable water and consumption through water-saving toilets that preserve water resources, energy efficient wastewater technology and wastewater treatment for recycling [35,48,49,51,55,56]. Treatment and reuse of wastewater for industry use can reduce the load on infrastructure and even defer upgrades [49,57,58].

Several synergies between sanitation and partnerships for the goals (SDG17) are a testament to eThekwini's strong partnerships at multiple scales including government, civil society, donors, multilateral organisations, and academia. At the international level, funding for specific activities in the 2019 National Water and Sanitation Masterplan is available from the Global Environmental Facility, Adaptation Fund and Green Climate Fund [48]. Multi-stakeholder partnerships include those between the Municipality, the Bill & Melinda Gates Foundation and Universities and Research centres (Bill & Melinda Gates Foundation, n.d.). Collaborations at city level include participation in the OPEN SDG Platform for localising SDGs where eThekwini exchanges knowledge and experiences with other city teams [59,60]. Other initiatives for working across government and civil society include the ISULABANTU toolkit and work conducted by EWS [61,62]. Numerous examples highlight the importance of partnerships for eThekwini to forge synergies between sanitation and other SDGs.

3.2. Wheel diagrams - risks

The authors identified risks between sanitation and the SDGs for 49 targets across 15 SDGs as shown in Fig. 3. Areas with more risks centre around poverty (SDG1), health (SDG3), education (SDG4), sustainable cities (SDG11) and peace, justice and strong institutions (SDG16). For two SDGs - affordable and clean energy (SDG7) and climate action (SDG13) no risks were identified.

Fig. 3. Risks between sanitation and SDGs in Durban (Based on the approach of Parikh et al. [27]).

Similar to synergies, multiple risks relate to how policies are implemented at the local level in relation to poverty and inequality. Sutherland et al. (2015) consider the differentiated service provision of EWS problematic as it could aggravate poverty and inequality. Further, the indigent policy is not always well targeted and tends to benefit relatively better-off households in several municipalities [63]. A study by Bond (2019b) questions the logic behind the provision of differential sanitation solutions for wealthier urban and suburban areas and informal settlements as technical, financial and ecological reasons are difficult to substantiate. This is corroborated in a study that finds sanitation services in South Africa to be unequal and inequitable when considering race, gender of head of household and settlement type and informal settlement residents often perceive their differential services as inferior [65]. Mkhize et al., (2017) highlight how lower-income groups aspire to the same infrastructural services as offered to higher-income populations: in-house flushed toilets and piped water. While residents are sensitive to differences in the type of sanitation technology, national and municipal monitoring and evaluation frameworks primarily focus on water and sanitation deficits, i.e., number of households without a basic level of service. The presence of a sanitation facility, however, does not guarantee access or quality of service if equity concerns are not considered (ibid).

Further risks link to poverty, inequality and health due to unsafe sanitation solutions and lack of participation. Studies show how non-functional sanitation solutions in informal settlements and toilets perceived unsafe for women and children lead to open defecation, environmental pollution and disease [40,67,68]. Lack of beneficiary involvement in choosing appropriate solutions have resulted in low levels of acceptance of UDT [66,69].

For goals specific to wastewater treatment plants, there are risks regarding operation and maintenance. A study found plants that are not properly operated and maintained or with leaks, contaminate water and land resources [70–72]. Furthermore, while wastewater sludge can provide benefits to agriculture, if the water is not adequately treated it contains potentially harmful chemicals and cannot be treated like other fertilisers [73].

3.3. Wheel diagrams - trade-offs

As shown in Fig. 4, the research identified trade-offs between sanitation and the goals related to clean water and sanitation (SDG6), affordable and clean energy (SDG7) and life on land (SDG15). Two trade-offs relate to use of resources. Firstly, water-intensive sanitation solutions pursued by the Municipality contribute to water scarcity [58]. Secondly, wastewater treatment plants with high energy use impact negatively on the environment [74]. The trade-off related to life on land indicates how effluent from wastewater treatment plants leads to nutrient pollution of rivers and dams and the proliferation of invasive species such as water hyacinth [57].

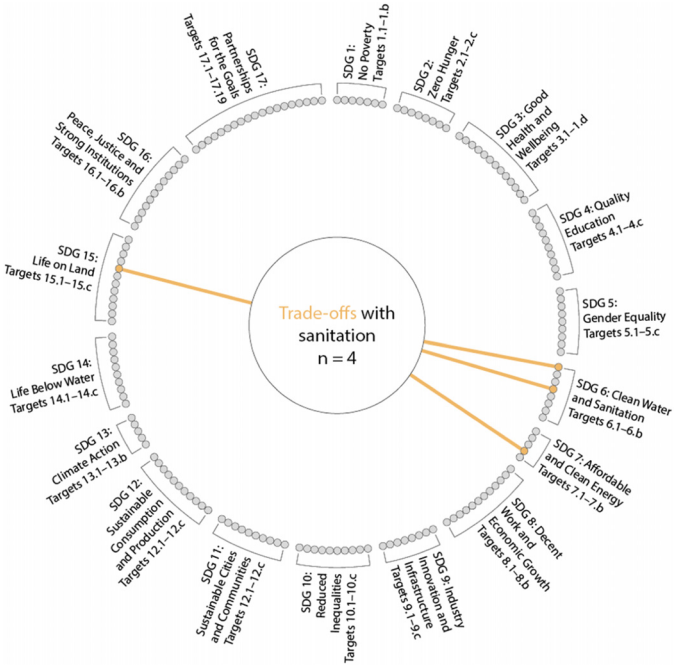

Fig. 4. Trade-offs between sanitation and the SDGs in Durban (Based on the approach of Parikh et al. [27]).

3.4. Nodes as key examples

Following a discussion of how sanitation is key to achieving all SDGs, this section provides a detailed examination of the complexity of interlinkages between targets for SDG 5 on gender equality; SDG 11 on sustainable cities and communities and SDG 13 on climate action (Fig. 5).

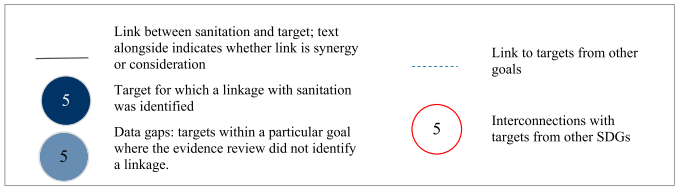

Fig. 5. Legend for node diagrams (example for SDG 5).

Fig. 5 clarifies how direct linkages and further interconnections with SDG targets as well as data gaps are represented in the node diagrams that follow.

3.5. Node on SDG 5 gender equality

As shown in Fig. 6, the synergies identified between sanitation and SDG 5 on gender equality highlight multiple ways in which sanitation action contributes to the achievement of SDG 5.

For instance, adequate sanitation facilities reduce the risk of gender-related violence on women and girls while addressing their basic needs and increasing their dignity. As mentioned in Section 3.1, locating toilets closer to people's homes can reduce sexual assaults (Gibbs et al 2021) while a study by Gonsalves et al. (2015) suggests that increased access to private, secure toilets can prevent non-partner sexual violence. Adequate sanitation in schools and sanitation policies that prioritise the physical and social needs of female students diminishes gender discrimination and reduces absenteeism [31,32,34]. The Municipality also fosters gender equality through CABs designed with separate access and services for women and girls and with adequate lighting and female caretakers to improve safety [50].

A study by Mottiar et al. (2011) shows the effectiveness of action by civil society organisations led by women around struggles for the right to basic water and sanitation, e.g. action by a women's organisation in a Durban township led to the Municipality adopting strategies in favour of community engagement and free water supply. Gounden and Alcock (2017) assert eThekwini's priority on gender equity including gender awareness. The predominant employment of women (75% of workers) in the implementation of local sanitation programmes and projects can significantly contribute to gender equality (ibid).

Nevertheless, there are risks that need to be considered as current sanitation solutions fail to incorporate Menstrual Hygiene Management (MHM).

Studies show how women and children revert to open defecation when toilet solutions are considered unsafe. This in turn poses health and pollution risks as settlements become open sewers after rain [67,68]. The risks identified further highlight that sanitation needs to be considered as a service, not just a physical facility, to ensure gender equality. For example, public toilets in taxi ranks or in markets are crucial for women and girls but often not maintained, cleaned or open when needed [76,77]. Women generally bear the burden of cleaning and maintaining sanitation infrastructure and facilities whether the solution is centralised or decentralised. However, the evidence review identified an increased burden on women associated with UDTs. Due to their gendered caring responsibilities, women have to assist children and the elderly in using these non-flushing toilets that separate urine from faeces and require the use of sand or ash to cover excrement immediately after use [64,75].

The node mapping further shows multiple data gaps, as there was no evidence for Durban on links between sanitation and five of the targets (targets 5.3, 5.5, 5.6, 5.a and 5.b) highlighting opportunities for future research. There is also no data regarding other vulnerable groups such as LGBTIQ+ and people with disabilities. This emphasises the binary nature of sanitation data, which focuses more on men, women, girls, and boys and can render the realities or multiple deprivations due to intersecting identities and relations of other vulnerable groups invisible.

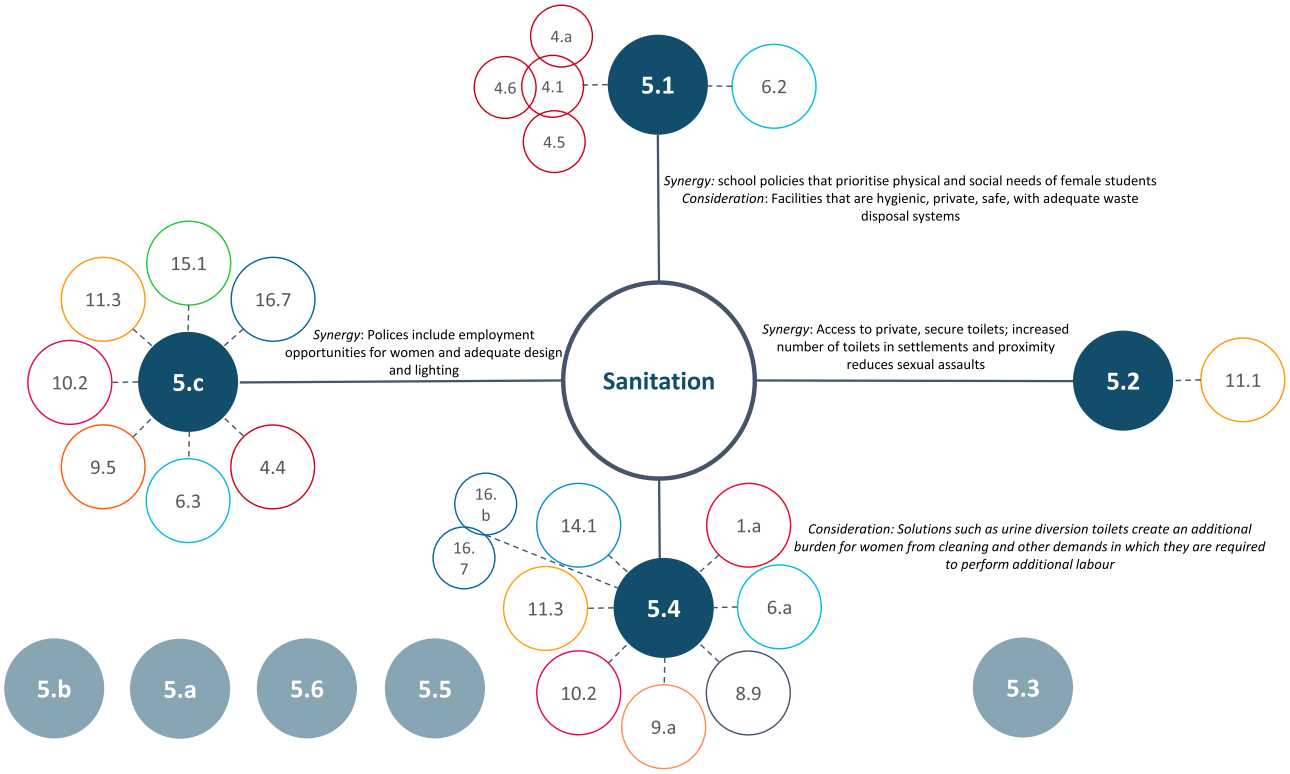

Fig. 6. Mapping of synergies, risks and interconnections with other targets, for Goal 5 Gender equality.

3.6. Node on SDG11, sustainable cities and communities

Fig. 7 highlights multiple links between sanitation and SDG11 on sustainable cities and communities. Like for SDG 5, the synergies and risks are articulated around the provision of infrastructure, governance and participation.

Targets focusing on adequate access to basic services and settlement upgrading are particularly relevant for eThekwini, with extensive

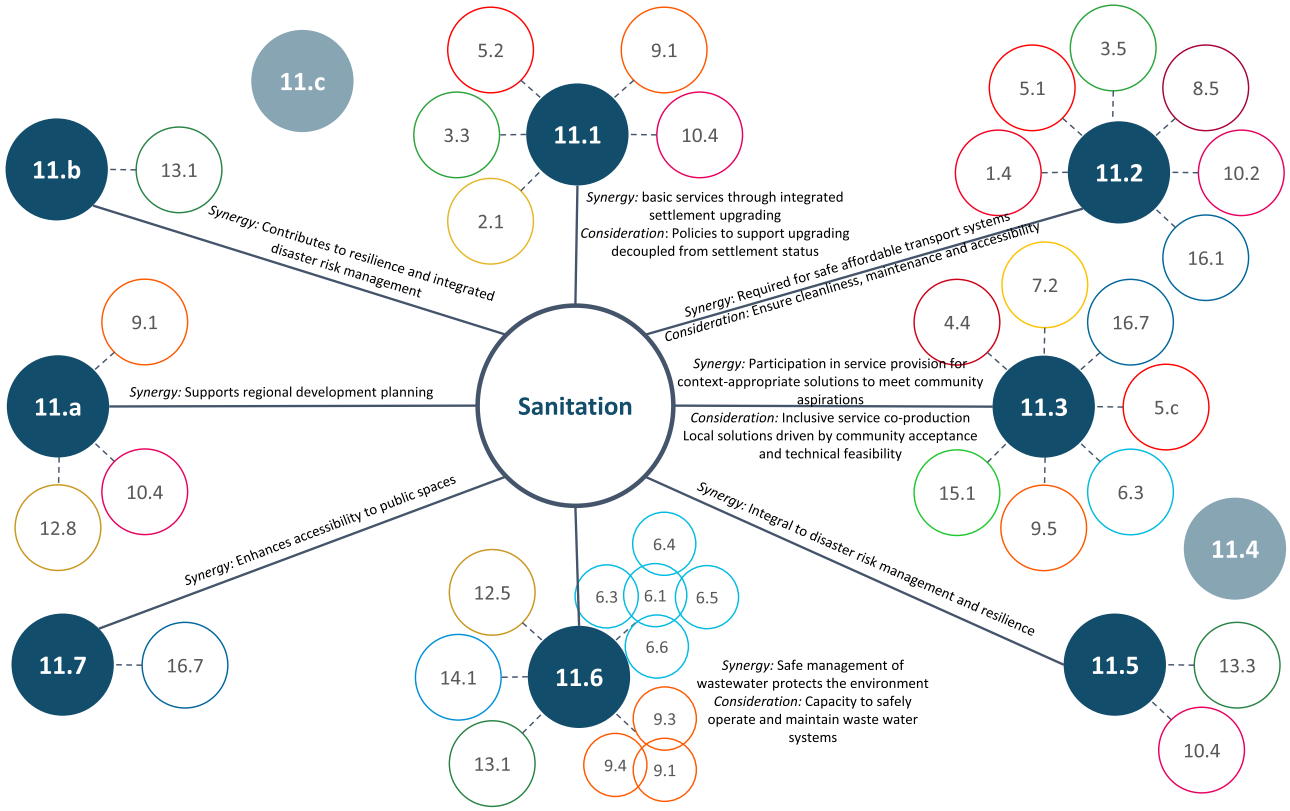

Fig. 7. Mapping of synergies, risks and interconnections with other targets, for Goal 11 Sustainable Cities and Communities.

literature on how the provision of sanitation contributes to achieving SDG 11 targets. Key issues include how sanitation is an essential part of settlement upgrading, transport systems and public spaces in the city [37]. Synergies relate to multiple other goals and targets, linking sanitation in settlement upgrading with combating communicable diseases, violence against women, ending hunger, sustainable infrastructure and policy for equality in cities [43,78,79].

For target 11.3 on inclusive and sustainable urbanisation multiple synergies were noted between sanitation and participation in service provision for context-appropriate solutions to meet community aspirations. Three separate studies document positive engagement between the Municipality and civil society. Alfers et al. [45] detail how local traders worked with the Municipality to improve sanitation in public spaces leading to better outcomes and enhanced relationships. Botha et al. [46] demonstrate how a local environmental monitoring committee elevated and resolved issues such as odour mitigation and faecal sludge management in collaboration with the facility's managers and the local community.

Extensive literature focuses on low acceptance rates of sanitation solutions such as UDTs and the need to engage with users to co-develop safe, acceptable and appropriate solutions [66,72,80]. This is mirrored by other research revealing that participatory governance in Durban needs to be strengthened through collective discussions on different sanitation options [63,67]. One study emphasised the need for engineers and city planners to involve citizens in decisions on appropriate solutions as the creation of facilitating committees after the selection of technical solutions is insufficient [69].

At a governance scale, there are synergies with national and municipal development planning focusing on sanitation in urban, peri-urban and rural areas [35] and policies and plans addressing climate change and resilience to disasters [81,82]. Synergies in policy include the need to increase capacity of the Disaster Management Unit, and ensure relocation of existing key infrastructure and people away from areas prone to flooding and landslide where necessary [81]. The work conducted by the Pollution Research Group of UKZN further exemplifies how action on sanitation contributes to SDG11 through scientific support to develop and implement innovative solutions while conserving the environment [79]. Risks are associated with the environmental impact of insufficiently treated wastewater from approximately 30% of the (51) wastewater treatment plants. This requires immediate action to prevent an outbreak of waterborne diseases, with short to medium term interventions needed for more than 66% of the plants [73].

3.7. Node on SDG13, climate action

As shown in Fig. 8 the evidence review identified synergies for SDG 13 on climate action, but no risks. The synergies differ to the other node mappings in that most interconnections are substantiated through policies and academic literature on resilience and disaster management. While the review found multiple documents on climate action in Durban, not many specifically referred to sanitation. This indicates insufficient context-specific data and literature on the topic rather than the lack of links. (Fig. 8).

The synergies point to policies that address climate action in relation to sanitation, referencing the precarity of sewage networks in the city and the vulnerability of informal settlements to flooding [82,83]. Other policies explore ecological and built water infrastructure opportunities in relation to climate resilience (including supporting the alternative and waterless sanitation revolution) [48]. Finally, there is evidence of institutional work, education and awareness raising towards climate change and sanitation [81]. Given the lack of evidence, further research is required for this goal.

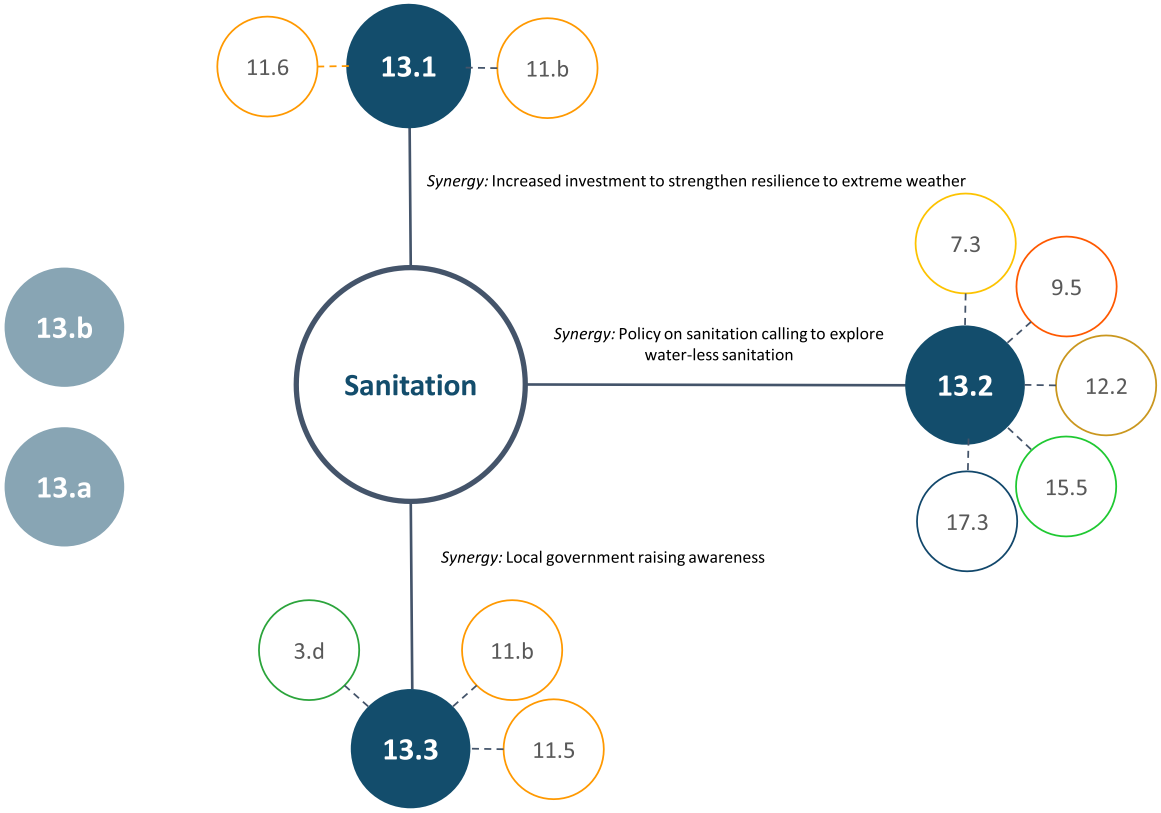

Fig. 8. Mapping of synergies and risks, as well as interconnections with other targets, for Goal 13 Climate Action.

4. Conclusion

In the first instance this work localises links between sanitation and SDGs for Durban and provides the evidence base to translate academic research into actionable points for policy makers. This study can be used to support current initiatives on sanitation in the Municipality and to identify priority areas based on the outcomes of the mapping. Areas with more linkages are not a representation of importance but make evident how multiple targets can be achieved through integrated efforts. The evidence-based review can support and strengthen resource allocation; and more specifically leverage resources for sanitation action based on evidence of multiple benefits across SDGs.

This research not only shows linkages between sanitation and all 17 SDGs, including 83 synergies, 49 risks and 4 trade-offs, but also interlinkages among SDG targets demonstrating the wide-ranging benefits of sanitation. The inclusion of risk as a new component of the mapping methodology can be incorporated in future research and adds a key analytical dimension when applying it in other contexts.

Our review reveals that lack of adequate sanitation in public spaces has implications for poverty, inequality, informality and dignity. Despite supportive policies, there is a need to enhance participation in decision-making to develop more appropriate sanitation solutions and enhance community acceptance. The provision of adequate facilities strongly links to women and children's safety and education. There is potential to explore the benefits of circular economy principles through improved resource recovery and reuse of treated wastewater and enterprise development in the sanitation sector. eThekwini's strong partnerships can be further leveraged for innovation in technical products and processes. Acceptance, operation and maintenance of technical solutions needs to be examined further especially in informal settlements. Data gaps exist for links between sanitation interventions and climate action for Durban, as well as sanitation data regarding particular vulnerable groups (e.g. LGBTQI+ and people with disabilities), which must be explored in future research.

Working with city officials as part of the core research team, and consultation with wider stakeholders, such as members of the SDG institutionalisation committee, allowed the project to draw on local expertise for the localisation of the SDGs. By localising the interconnections between SDGs through concrete evidence, the research addresses an important gap in the literature on SDG localisation approaches in the global South as cities need to deliver services and track and report on progress. Furthermore, it emphasises the need for quality, accessible and relevant data to support progress on monitoring and reporting on the SDGs.

In the longer term, the research has potential to influence thinking on how improved policies for sanitation can deliver benefits across the SDGs to all its citizens irrespective of land ownership or socio-demographic profile. Lessons and outputs from this study can be used for localisation of SDGs in other settings and applied to other sectors such as water, health, climate, energy and human settlements.

Most importantly, this study provides the evidence to make the case of why sanitation action and investment in Durban is vital and how it can lead to multiple benefits across all 17 Goals.

Ethics statement

On behalf of all authors I declare that we have followed the guidelines for ethics in publishing as outlined below. We have not used primary data sources for this study. https://www.elsevier.com/about/policies/publishing-ethics#Authors

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Dr. Parikh gratefully acknowledges her Bboxx/Royal Academy of Engineering Senior Research Fellowship, grant number [RCSRF1819\8\38].

Professor Lakhanpaul acknowledges support from NIHR GOSH BRC.

The team from the eThekwini Municipality wishes to acknowledge the contribution of the members of the eThekwini SDG Institutionalisation committee, the Water Research Commission, Umgeni Water and the Council for Scientific and Industrial Research.

Funding

This project was funded by UCL Grand Challenges and the Global Engagement Office at UCL.

UCL Grand Challenges convenes and cultivates cross-disciplinary collaborations that explore interconnected solutions in six areas related to matters of pressing societal concern. https://www.ucl.ac.uk/grand-challenges/about-ucl-grand-challenges.

The Global Engagement Office at UCL aims to increase UCL's global impact and puts partnerships of equivalence at the heart of everything they do. https://www.ucl.ac.uk/global/.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.wds.2022.100038.

References

[1] United Nations, Sustainable Development Goals, Sustainable Development Goals. (2021). https://www.un.org/sustainabledevelopment/water-and-sanitation/ (accessed November 10, 2021).
[2] World Bank Group, Delivering Rural Sanitation Programs at Scale, with Equity and Sustainability - Rising up to the Sanitation Ambition, (2019).
[3] UNICEF, UNICEF Data Warehouse, UNICEF Data: Monitoring the Situation of Children and Women. (2021). https://data.unicef.org/resources/data_explorer/unicef_f/?ag=UNICEF&df=GLOBAL_DATAFLOW&ver=1.0&dq=.WS_HCF_WM-N+WS_HCF_WM-L+WS_HCF_H-L+WS_HCF_C-L+WS_HCF_C-B+WS_HCF_H-N+WS_HCF_H-B+WS_HCF_S-B+WS_HCF_WM-B+WS_HCF_W-B+WS_HCF_W-L+WS_HCF_S-N+WS_HCF_S-L+WS_HCF_C-N+WS_HCF_W-N+WS_PPL_W-SM+WS_PPL_S-SEW+WS_PPL_W-UI+WS_PPL_H-L+WS_PPL_S-WWT+WS_PPL_W-B+WS_PPS_S-OD+WS_PPL_W-QUA+WS_PPL_W-I+WS_PPL_W-ALB+WS_PPL_S-DIS+WS_PPS_S-UI+WS_PPL_H-N+WS_PPL_S-LAT+WS_PPL_W-PRE+WS_PPL_W-L+WS_PPL_S-SEP+WS_PPL_W-P+WS_PPL_S-B+WS_PPL_S-SM+WS_PPL_S-L+WS_PPL_S-FST+WS_PPL_W-AVA+WS_PPL_W-NP+WS_PPL_S-ALB+WS_PPL_W-SW+WS_PPL_H-B+WS_PPL_S-I+WS_SCH_H-L+WS_SCH_S-B+WS_SCH_H-N+WS_SCH_S-L+WS_SCH_W-B+WS_SCH_S-N+WS_SCH_W-L+WS_SCH_W-N+WS_SCH_H-B..&startPeriod=2016&endPeriod=2019 (accessed November 10, 2021).
[4] Department of Water and Sanitation, National Sanitation Policy 2016, (2016).
[5] Stats SA, General Household Survey 2019, (2020).
[6] eThekwini Municipality, eThekwini Municipality Annual Report 2019-2020, (2020).
[7] eThekwini Municipality, eThekwini Integrated Development Plan 2020/21, (2021).
[8] eThekwini Municipality, Council Decision Circular: Meeting Held on 2020-06-04, (2020).
[9] C. Sutherland, D. Scott, M. Hordijk, Urban water governance for more inclusive development: a reflection on the 'Waterscapes' of Durban, South Africa, Eur. J. Dev. Res. 27 (2015) 488–504, doi:10.1057/ejdr.2015.49.
[10] Department Provincial and Local Government, National Framework for Municipal Indigent Policies, (n.d.). https://www.westerncape.gov.za/text/2012/11/national_framework_for_municipal_indigent_policies.pdf.
[11] M. Muller, Free basic water — a sustainable instrument for a sustainable future in South Africa, Environ. Urban. 20 (2008) 67–87, doi:10.1177/0956247808089149.
[12] C. Sutherland, M. Hordijk, B. Lewis, C. Meyer, S. Buthelezi, Water and sanitation provision in eThekwini Municipality: a spatially differentiated approach, Environ. Urban. 26 (2014) 469–488, doi:10.1177/0956247814544871.
[13] Stockholm International Water Institute, "Most progressive water utility in Africa" receives 2014 Stockholm Industry Water Award", World Water Week. (2014). https://www.worldwaterweek.org/news/most-progressive-water-utility-in-africa-receives-2014-stockholm-industry-water-award (accessed August 2, 2022).
[14] Ingonyama Trust Board, Ingonyama Trust Board, Ingonyama Trust Board. (2019). http://www.ingonyamatrust.org.za/(accessed August 2, 2022).
[15] eThekwini Municipality, Ethekwini Municipality Indigent Policy, (2020).
[16] J. Coenen, L.-M. Glass, L. Sanderink, Two degrees and the SDGs: a network analysis of the interlinkages between transnational climate actions and the Sustainable Development Goals, Sustain. Sci. (2021), doi:10.1007/s11625-021-01007-9.

[17] J. Waage, C. Yap, S. Bell, C. Levy, G. Mace, T. Pegram, E. Unterhalter, N. Dasandi, D. Hudson, R. Kock, S. Mayhew, C. Marx, N. Poole, Governing the UN Sustainable Development Goals: interactions, infrastructures, and institutions, Lancet Global Health 3 (2015) e251–e252, doi:10.1016/S2214-109X(15)70112-9.
[18] K. Andersson, A. Rosemarin, B. Lamizana, E. Kvanstrom, J. McConeville, R. Seidu, S. Dickin, C. Trimmer, Sanitation, Wastewater Management and Sustainability: From Waste Disposal to Resource Recovery, UNEP/SEI. (2016).
[19] N. Libala, A. Nyingwa, N. Griffin, Mapping Water and Sanitation Interlinkages across the Sustainable Development Goals, Water Research Commission, South Africa, 2021.
[20] C. Allen, M. Smith, M. Rabiee, H. Dahmm, A review of scientific advancements in datasets derived from big data for monitoring the Sustainable Development Goals, Sustain Sci 16 (2021) 1701–1716, doi:10.1007/s11625-021-00982-3.
[21] S. Fox, A. Macleod, Localizing the SDGs in cities: reflections from an action research project in Bristol, UK, Urban Geography. (2021) 1–21. doi:10.1080/02723638.2021.1953286.
[22] E. Bromaghim, A. Kim, How universities can help cities achieve the Sustainable Deveopment Goals, Apolitical. (2020). https://apolitical.co/solution-articles/en/universities-cities-sustainable-development (accessed November 29, 2021).
[23] S. Croese, C. Green, G. Morgan, Localizing the Sustainable Development Goals Through the Lens of Urban Resilience: Lessons and Learnings from 100 Resilient Cities and Cape Town, Sustainability 12 (2020) 550, doi:10.3390/su12020550.
[24] K. Hartley, Infrastructure and SDG localization: the 21st century mandate, Environ. Res.: Infrastruct. Sustain. 2 (2022) 013001, doi:10.1088/2634-4505/ac442a.
[25] S. Mbatha, B. Khanyile, A data-driven approach towards accelerating SDG local progress and action, Apolitical. (2021). https://apolitical.co/solution-articles/en/data-driven-approach-accelerating-sdg-local-progress-action (accessed November 29, 2021).
[26] S. Croese, C. Wright, N. Primo, Localisation of the 2030 Agenda and its Sustainable Development Goals in Cape Town, (n.d.) 27.
[27] P. Parikh, L. Diep, P. Hofmann, J. Tomei, L.C. Campos, T.-H. Teh, Y. Mulugetta, B. Milligan, M. Lakhanpaul, Synergies and Trade-offs between Sanitation and the Sustainable Development Goals, 2021. doi:10.14324/111.444/000054.v1.
[28] R. Dyer, L. Zuma, T. Gounden, N. Prishah, S. Mashiyane, 2021 eThekwini Municipality Sanitation Policy, (2021).
[29] F.F. Nerini, J. Tomei, A. Borrion, C. Spataru, V. Castan-Broto, G. Anandarajah, Y. Mulugetta, ENERGY AND THE SUSTAINABLE DEVELOPMENT GOALS, (n.d.) 12.
[30] L. Diep, F.P. Martins, L.C. Campos, P. Hofmann, J. Tomei, M. Lakhanpaul, P. Parikh, Linkages between sanitation and the sustainable development goals: a case study of Brazil, Sustain. Develop. 29 (2021) 339–352, doi:10.1002/sd.2149.
[31] B. Devnarain, C.R. Matthias, Poor access to water and sanitation: consequences for girls at a rural school, Agenda 25 (2011) 27–34, doi:10.1080/10130950.2011.575993.
[32] N. Abrahams, S. Mathews, P. Ramela, Intersections of “sanitation, sexual coercion and girls” safety in schools, Trop. Med. Int. Health 11 (2006) 751–756, doi:10.1111/j.1365-3156.2006.01600.x.
[33] N.D. Ngidi, R. Moletsane, Bullying in school toilets: Experiences of secondary school learners in a South African township, SAJE 38 (2018) S1–S8, doi:10.15700/saje.v38ns1a1588.
[34] T.L. Crankshaw, M. Strauss, B. Gumede, Menstrual health management and schooling experience amongst female learners in Gauteng, South Africa: a mixed method study, Reprod Health 17 (2020) 48, doi:10.1186/s12978-020-0896-1.
[35] T. Gounden, B. Pfaff, N. Macleod, C. Buckley, Provision of Free Sustainable Basic Sanitation: The Durban Experience, in: 2006: p. 5.
[36] I.W. Bailey, L. Archer, The impact of the introduction of treated water on aspects of community health in a rural community in Kwazulu-Natal, South Africa, Water Sci. Technol. 50 (2004) 105–110, doi:10.2166/wst.2004.0031.
[37] P. Cunnan, B. Maharaj, Against the odds: Health care in an informal settlement in Durban, Dev. South. Afr. 17 (2000) 667–686, doi:10.1080/713661430.
[38] S.D.C., Environmental Alliance, Feeling the Heat in Durban, Capital. Nat. Social. 22 (2011) 50–73, doi:10.1080/10455752.2011.618251.
[39] R.D. Lutchminarayan, Sanitation, Water and Hygiene in eThekwini Municipality, Durban, South Africa: A Baseline Cross-Sectional Study, University of KwaZulu-Natal, Durban, 2007.
[40] Z. Mbonambi, An Investigation into the Environmental Impacts of Informal Settlements on Water: a Case of Kennedy Road Informal Settlement in Durban, KwaZulu Natal, University of KwaZulu-Natal, Durban, n.d.
[41] S.-A. McGee, L. Chola, A. Tugendhaft, V. Mubaiwa, N. Moran, N. McKerrow, L. Kamugisha, K. Hofman, Strategic planning for saving the lives of mothers, newborns and children and preventing stillbirths in KwaZulu-Natal province South Africa: modelling using the Lives Saved Tool (LiST), BMC Public Health 16 (2015) 49, doi:10.1186/s12889-015-2661-x.
[42] Citywide inclusive sanitation: Durban, South Africa, 2018. https://www.youtube.com/watch?v=26T_SI2XXdg&list=PLa16GBkPGYKv4n_a0BcKB_hUYMdiQVH55&index=15.
[43] A. Gibbs, T. Reddy, D. Khanyile, C. Cawood, Non-partner sexual violence experience and toilet type amongst young (18–24) women in South Africa: A population-based cross-sectional analysis, Glob. Public Health 16 (2021) 590–596, doi:10.1080/17441692.2020.1813787.
[44] G.S. Gonsalves, E.H. Kaplan, A.D. Paltiel, Reducing sexual violence by increasing the supply of toilets in Khayelitsha, South Africa: a mathematical model, PLoS One 10 (2015) e0122244, doi:10.1371/journal.pone.0122244.
[45] L. Alfers, P. Xulu, R. Dobson, Promoting workplace health and safety in urban public space: reflections from Durban, South Africa, Environ. Urban. 28 (2016) 391–404, doi:10.1177/0956247816647845.
[46] M.F. Botha, S.L. Biyela, M.R. Fry, R. Paladh, Sewage-sludge incineration in South Africa using a fluidized-bed reactor, (2011) 9.
[47] P. Parikh, I. Bisaga, C. Loggia, M.C. Georgiadou, J. Ojo-Aromokudu, Barriers and opportunities for participatory environmental upgrading: case study of Havelock informal settlement, Durban, City Environ Interact. 5 (2020) 100041, doi:10.1016/j.cacint.2020.100041.
[48] Department of Water and Sanitation, National water and sanitation master plan, Volumen One: Call for Action (2018) 403.
[49] M. Jacobsen, M. Webster, K. Vairavamoorthy, Waste Water, From Waste to Resource, The World Bank, 2012, doi:10.1596/978-0-8213-9721-3.
[50] T. Gounden, N. Alcock, Sustainable FSM services through integrated use of resources and innovative technologies: a case study of the eThekwini Municipality (Durban) South Africa, 2017.
[51] S. Moodliar, Implementation of Green Technology in Ethekwini, (n.d.). https://www.assaf.org.za/files/Conference%20Presentations/The%20State%20of%20Water%20in%20Southern%20Africa/The%20State%20of%20Green%20Technologies%20Study/Implementation%20of%20Green%20Technology%20in%20Ethekwini.pdf (accessed May 24, 2021).
[52] Seesaw, Community-based monitoring system tracking the functionality of a bio-mimicry wastewater system, n.d. https://greenseesawcom.files.wordpress.com/2018/03/experience-profile_-gos.pdf (accessed June 14, 2021).
[53] G. Austin, Biogas energy and sanitation provision in South Africa, ESI Africa (2003) 3.
[54] DW&S SA, National Sanitation Policy, (2016).
[55] S. Sewchurran, I.E. Davidson, Study of renewable energy resources found within local municipalities: An eThekwini municipality case study, in: 2017 IEEE PES PowerAfrica, IEEE, Accra, Ghana, 2017, pp. 220–226, doi:10.1109/PowerAfrica.2017.7991227.
[56] M. Grau, B. Etter, K.M. Udert, C.J. Brouckaert, Development and operation of struvite reactors to recover phosphorous from source separated urine in eThekwini, (n.d.) 3.
[57] Environmental Planning and Climate Protection Department, Water Hyacinth Control: Insights into Best Practice, Removal Methods, Training & Equipment, (n.d.).
[58] K. Trollip, L. Van Vuuren, South Africa, Water Research Commission, Knowledge for impact: research for successful service delivery at the local government level, 2016.
[59] A.F. Pipa, Shaping the Global Agenda to Maximize City Leadership on the SDGs. The Experiences of Vanguard Cities, Brookings, 2019.
[60] Slum Dwellers International, National Community Exchange – Durban to Cape Town, (2014). https://sdinet.org/2014/05/national-community-exchange-durban-to-cape-town/(accessed June 15, 2021).
[61] M. Galvin, Leaving boxes behind: Civil society and water and sanitation struggles in Durban, South Africa, Transformation 92 (2016) 111–134, doi:10.1353/trn.2016.0029.
[62] M.C. Georgiadou, C. Loggia, I. Bisaga, P. Parikh, Towards sustainable informal settlements: a toolkit for community-led upgrading in Durban, in: Proceedings of the Institution of Civil Engineers - Engineering Sustainability, 174, 2021, pp. 83–93, doi:10.1680/jensu.20.00040.
[63] OECDOECD Environmental Performance Reviews: South Africa 2013, OECD, 2013, doi:10.1787/9789264202887-en.
[64] P. Bond, Tokenistic water and neoliberal sanitation in post-apartheid Durban, J. Contemp. Afr. Stud. 37 (2019) 275–293, doi:10.1080/02589001.2019.1710115.
[65] S.M. Pan, N.P. Armitage, M.B. van Ryneveld, Assessing equity: a way to improve sanitation service delivery in South African informal settlements, J. Water, Sanitat. Hyg. Develop. 8 (2018) 429–438, doi:10.2166/washdev.2018.166.
[66] N. Mkhize, M. Taylor, K.M. Udert, T.G. Gounden, C.A. Buckley, Urine diversion dry toilets in eThekwini Municipality, South Africa: acceptance, use and maintenance through users’ eyes, J. Water, Sanitat. Hyg. Develop. 7 (2017) 111–120, doi:10.2166/washdev.2017.079.
[67] C. Sutherland, L. Bonang, M. Hordijk, C. Meyer, D. Scott, Community adaptation and innovative water and climate change policies in Durban (South Africa): an encounter in relational space, in: n.d.
[68] L. Van Vuuren, Sanitation and health, 2016.
[69] F. Salisbury, C. Brouckaert, D. Still, C. Buckley, Multiple criteria decision analysis for sanitation selection in South African municipalities, WSA. 44 (2018). doi:10.4314/wsa.v44i3.12.
[70] CSIR, A CSIR Perspective on Water in South Africa, (2010).
[71] V. Mema, Impact of Poorly Maintained Wastewater and Sewage Treatment Plants: Lessons from South Africa, n.d.
[72] J. Tempelhoff, A first generation African community grappling with urbanisation: the views of Platfontein’s San on water and sanitation service delivery, TDSA (2014) 10, doi:10.4102/td.v10i4.88.
[73] H.G. Snyman, A. van Niekerk, N. Rajasakran, Sustainable Wastewater Treatment - What has gone wrong and how do we get back on track?, (n.d.) 11.
[74] E. Friedrich, S. Pillay, C.A. Buckley, Carbon footprint analysis for increasing water supply and sanitation in South Africa: a case study, J. Clean. Product. 17 (2009) 1–12, doi:10.1016/j.jclepro.2008.03.004.
[75] S. Mottiar, O. Naidoo, D. Khumalo, Women’s organisations and the struggle for water and sanitation services in Chatsworth and Inanda, Durban: The Westcliff Flats Residents Association and the Didiyela Women’s Group, Agenda 25 (2011) 122–130, doi:10.1080/10130950.2011.576005.
[76] G. Ardé, Durban, the city that forces the poor to defecate in the streets, (2019) 6.
[77] Z. Dawood, Taxi rank toilets ’deplorable’ after eThekwini funding stops, (2020) 2.

[78] K. Breetzke, From Conceptual Frameworks to Quantitative Models: Spatial planning in the Durban metropolitan area, South Africa–the link to housing and infrastructure planning, South Africa. (2009) 22.
[79] Pollution Research Group University of KwaZuluNatal, Research collaboration on water and sanitation delivery, (n.d.). http://prg.ukzn.ac.za/projects/funded-by-ethekwini-water-and-sanitation (accessed July 6, 2021).
[80] P. Bond, Contradictory time horizons of Durban energy piping in an era of looming climate chaos, City 23 (2019) 631–645, doi:10.1080/13604813.2019.1689734.
[81] D. Roberts, Prioritizing climate change adaptation and local level resilience in Durban, South Africa, Environ. Urban. 22 (2010) 397–413, doi:10.1177/0956247810379948.
[82] D. Roberts, Thinking globally, acting locally — institutionalizing climate change at the local government level in Durban, South Africa, Environ. Urban. 20 (2008) 521–537, doi:10.1177/0956247808096126.
[83] Environmental Planning, Climate Protection Department, Office Energy, Durban Climate Change Strategy, South Africa (2014).