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Broad Brush Surveys: a rapid qualitative assessment approach for water and sanitation infrastructure in urban sub-Saharan cities

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Introduction: Broad Brush Surveys (BBS) are a rapid, qualitative assessment approach using four meta-indicators -physical features, social organization, social networks and community narratives - to gauge how local context interfaces with service/intervention options, implementation and uptake.

Methods: In 2021, responding to rapid urbanization and the accompanying need for water and sanitation services, BBS was innovatively applied by social scientists and engineers to assess water and sanitation infrastructure, both formal and informal, in two African cities - Lusaka and Cape Town. In four urban communities, identified with local stakeholders, BBS data collection included: four mapping group discussions with local stakeholders (participants = 24); eight transect walks/drives; 60 structured observations of water and sanitation options, transport depots, health facilities, weekends, nights, rainy days; seven mixed gender focus group discussions (FGDs) with older and young residents (participants = 86); 21 key-informant interviews (KII, participants = 21).

Results: Findings were rapidly summarized into community profiles, including narrative reports, maps and posters, and first discussed with community stakeholders, then at national/provincial levels. The meta-indicator framework and set sequence of qualitative activities allowed the detail on water and sanitation to gradually emerge. For example, the mapping discussion identified water sources considered a risk for waterborne infections, further observed in the transect walks and then structured observations, which compared their relative condition and social interactions and what local residents narrated about them. FGDs and KIIs elaborated on the control of these sources, with nuanced detail, including hidden sources and the use of different water sources for different activities also emerging.

Discussion: We demonstrated that despite some limitations, BBS provided useful insight to systems and social processes surrounding formal and informal water and sanitation infrastructure in and across designated urban areas. Furthermore, BBS had the potential to galvanize local action to improve infrastructure, and illuminated the value of informal options in service delivery.

KEYWORDS

Broad Brush Survey, water and sanitation infrastructure, Zambia, South Africa, meta-indicators, community-based research

1. Introduction

In sub-Saharan Africa (SSA), rapid urbanization has been driven by population expansion, migration from fragile states, rural-urban mobility, urban development and, more recently, COVID-19 related economic hardship (WHO, 2017; Ohwo and Agusomu, 2018; Simukonda et al., 2018; Enqvist and Ziervogel, 2019). This urbanization has been accompanied by an increase in unplanned settlements and added pressure on planned settlements, amplifying inadequate access to water and sanitation infrastructure (Ato Armah et al., 2018; Ohwo and Agusomu, 2018; Enqvist and Ziervogel, 2019; Priya et al., 2019). Rapid assessment of both infrastructure and access at community level, for pragmatic planning of water and sanitation infrastructure interventions, could help communities, municipal authorities and other stakeholders better manage water and sanitation delivery.

Cape Town, South Africa and Lusaka, Zambia provide an interesting comparison on urbanization. In Cape Town, as elsewhere in South Africa, service expansion and access initiatives are central to redressing the legacy of apartheid, and part of the government led Residential Development Programme (RDP) that has built houses for residents of informal settlements (Govender et al., 2011; Shackleton et al., 2014; Fransolet, 2015; Amin and Cirolia, 2018). Despite this investment, water and sanitation service provision has been confronted by vandalism, crime, misappropriation and shortage of public funds, poor quality and/or temporary infrastructure, low-lying and flood prone land, and water shortages linked to drought (McFarlane and Silver, 2017; Madonsela et al., 2019; Robins, 2019; Loubser et al., 2021). In Lusaka, 70% of the city's three million population live in unplanned settlements (Simukonda et al., 2018; NDP, 2022; UN Habitat, 2023). As unplanned settlements have continued to expand in Lusaka, formal service delivery has proved inadequate. Furthermore, the decentralization of water and sanitation delivery to local authorities and private companies (Chitonge, 2011; NWASCO, 2021), uneven and short-term development initiatives, and poor governance in the city have resulted in poor infrastructure and record keeping, inadequate maintenance (leading to water theft and leakage and unsafe infrastructure), and water-borne disease outbreaks (Chitonge, 2011; Kennedy-Walker et al., 2015; Loubser et al., 2021). Faced by inequitable access to formal services, residents of these two SSA cities often have to fill the gap left by government and non-governmental organizations (NGOs) by developing "informal" options and practices to access water and sanitation (Maryati et al., 2018; Nabirye et al., 2023). "Formal" and "informal" infrastructure can be distinguished by defining formal as infrastructure linked to governmental and NGO initiatives, and "informal" as alternative infrastructure initiatives that emerge in the communities alongside the formal (Maryati et al., 2018; Nabirye et al., 2023). The informal have often been left out of more conventional assessments of water and sanitation infrastructure.

Criticism against the Sustainable Development Goal 6 (SDG6) Clean Water and Sanitation has been widely raised, considering that access to safe water and sanitation are still lacking for 2.3 billion people and 4.5 billion respectively (Burton et al., 2021; Sutherland et al., 2021). A contributing factor to not achieving SDG6 is attributed to the slow integration of social and physical sciences to understand and improve water and sanitation management (Lund, 2015). Economic-social and economic-environmental linkages have received more attention than social-environmental (Rambaree et al., 2019; Mandelli, 2022). To gain a more comprehensive, contextual understanding of access to water and sanitation infrastructure requires using qualitative, local perspectives by utilizing the human-focused research approach of social sciences (Workman et al., 2021). Furthermore, integrating social sciences with engineering and physical sciences for water and sanitation could further help to facilitate social action and change to improve water and sanitation infrastructure and enhance wellbeing (Rambaree et al., 2019).

In this analysis, we integrate social and physical sciences in response to water and sanitation infrastructure challenges. We present the application of a rapid qualitative assessment approach, termed Broad Brush Surveys (BBS), by an interdisciplinary team of social scientists and engineers, to context-specific water and sanitation infrastructure challenges in Lusaka and Cape Town. Rapid data collection through adapted qualitative methods is not a novel concept, as social scientists have increasingly faced pressure to produce results within shorter timeframes compared to conventional ethnographic approaches (Sangaramoorthy and Kroeger, 2020). The BBS approach consists of a set sequence of qualitative data collection activities rooted in sociological observations of urban communities and focusing on four meta-indicators: physical features, social organization, social networks, and community narratives (Srivastava and Hopwood, 2009; Palinkas et al., 2015; Busetto et al., 2020). The application of this meta-indicator detail to the research question or public health issue at hand, and systematic comparison across geographically bounded communities within a short timeframe, has proved useful to informing study/intervention design, implementation and interpretation in public health research (Murray et al., 2009; Bond et al., 2013, 2016, 2019).

This paper contributes to the interdisciplinary body of knowledge on the interaction between growing urbanization in SSA cities, water and sanitation and their broader environmental implications. The importance of considering both the socio-economic and environmental factors when planning and implementing water and sanitation infrastructure projects in similar contexts is underscored (Frank et al., 2017; Priya et al., 2019). We argue that the BBS approach was pragmatic for demonstrating the eco-social and interdisciplinary value of this research. Further, the BBS approach also provided insights on community perspectives and reasons for using both formal and informal water and sanitation systems in four urban communities in Cape Town and Lusaka.

2. Methods

2.1. The Broad Brush Survey (BBS) approach and the meta-indicator framework

The study adapted a Broad Brush Survey (BBS) approach to assess formal and informal water and sanitation infrastructure in four urban communities, two in Lusaka and two in Cape Town. BBS aims to rapidly generate comparative community profiles for different disciplines and audiences around a key issue for the purpose of research and/or intervention. BBS uses a set sequence of qualitative activities and methods to gather qualitative data on four meta-indicators of a geographically bounded place: physical features, social organization, social networks and community narratives. During 5–15 days of fieldwork, the data from the sequence of qualitative activities are regularly debriefed by a research team (usually social scientists and local fieldworkers) and summarized, allowing for iterative interpretation and enquiry (Palinkas et al., 2015; Busetto et al., 2020). The research team thus builds a profile of the community to reach a more nuanced, although rapid, description that is revised and completed soon after fieldwork. The community profiles are then presented in brief outputs to share and discuss with relevant stakeholders. Following this engagement, the BBS data is more finely managed, analyzed and written up, sometimes being used in more mixed-methods analyses if the BBS is part of a larger research study. BBS often accompanies community engagement as one of the first activities of larger research studies, but can also be a stand-alone assessment for research or intervention.

Thus, the meta-indicators framework forms a multi-layered description that moves from a broad to a more focused understanding of the issue at hand both through linking each indicator to research specific detail, and by building a layered understanding of both the place and the specific research/intervention focus. Table 1 is adapted from Wallman et al. (2011) and summarizes the four meta-indicators. See also Bond et al. (2019) for the history of the BBS approach and the application of BBS within six public health studies in SSA, and see the BBS Manual v1 (Bond et al., 2023).

For this study, we aimed to demonstrate if BBS was an efficient and replicable approach to usefully gauge the relationship between local residents and water and sanitation infrastructure. We innovatively adapted the BBS approach to water and sanitation infrastructure with water engineers, who were involved from the concept onwards in the aim, objectives, tool content, graduate researcher selection and supervision, stakeholder engagement, fieldwork, analysis and dissemination.

2.2. Selection of study sites

Selection of sites was by pre-determined study criteria, background research, and thorough consultations with political and water, sanitation and hygiene (WASH) stakeholders. The study aimed to select urban communities within each city that were: a mix of planned and unplanned areas; sufficiently different to one another; new areas for each of the research institutes to work in; and identified by WASH stakeholders in each city as useful for broader WASH development issues.

Gray literature from sources of information, including, government reports, Google maps, and internet searches, were used to identify potential communities that fitted the study criteria. For each potential community, a profile was detailed that included: geographical boundaries and adjacent communities, ground area, the date the community was established, housing types, demographic profile, socio-economic characteristics, geographic topography, land utilization, services and resources, and identified issues and challenges. Thereafter, the study was introduced to and discussed with ward councilors and other municipal authorities, who then determined the final selection of communities. Through this selection process, we gained municipal approval to work in four communities anonymized as Z1 and Z2 in Lusaka, Zambia and S3 and S4 in Cape Town, South Africa.

2.3. Research team, training, and fieldwork time frame

In each country, a mix of social scientists and engineers were recruited as researchers, supported by more experienced researchers from both disciplines. BBS training was conducted remotely due to COVID-19 travel restrictions. The training took place over 10 days, with online sessions between 1 to 3 h, off-line practice session activities, and separate institutional ethical training in each country. The training included introduction to BBS, community entry and stakeholder engagement, sequence of activities and tools, core methods skills (observation, key-informant interviews, focus group discussions, mapping), core water and sanitation infrastructure in each country, ethics, data management, and report writing.

The fieldwork research teams consisted of a social scientist and engineering graduate pair and research assistants. In Zambia, Local Fieldworkers (LFWs) were appointed as research assistants to support the graduate pair with the fieldwork and were trained for a day in each community, and during the fieldwork itself. Having LFWs was useful to help the graduate social scientist and engineer to recruit research participants, accompany them on, and assist with, research activities, approach households in the community, and answer questions about the research. LFWs would also guide the researchers about language or cultural issues,

TABLE 1 Meta-indicators framework (adapted from Wallman et al., 2011, pp. 204–205).

Meta-indicator	Definition	Question relevant to problem management
Physical features	*"Material fabric of the local area"*. Visible, countable, mappable. Includes: housing types, other architectural features, employment and work options, physical boundaries, topography (bird's eye view).	What could happen here? What are the features of particular relevance to the problem?
Social organization	*"Relation of people to place"*. The organization of people in the place, across housing, work, mobility (access to transport, movement in/out of community). Characteristics of population diversity, age, ethnicity, family structure, socio-economic status.	How are people organized in this place? How are people organized in relation to the problem?
Social networks	*"Relation of people to people in this place"*. Links between people and groups. Patterns of interaction for example ethnic/local, chosen/ascribed. Extensive/intensive networks. Bonding/bridging social capital. Flexible/fixed network boundaries. Networks of services (formal and informal).	What are the patterns of interaction between people within and outside of the community? What networks are relevant and active for the problem?
Community narratives	*"What do people say about this place?"* Oral history (origin, style), identify with the place, commitment to the place (chosen/no choice), blaming patterns, butt of gossip.	What kind of place is this in local narratives? What are people's opinions about the problem?

help identify places of significance to WASH and alert where it was safe or dangerous to move around. In South Africa, research assistants were students from Stellenbosch University who attended the BBS training.

Between June and December 2021, the social scientist and engineering graduate pair in each country conducted BBS fieldwork with the research assistants in a period of 12–15 days in each study community. In both countries, the COVID-19 pandemic interrupted fieldwork in various ways including government and/or institutional closure of research during waves and/or lockdown and COVID infection and illness in study staff. When fieldwork took place, institutional COVID-19 Standard Operating Procedures and policies were followed and included regular testing of study staff, staff wearing masks, and providing participants with access to masks and hand-washing facilities, using well-ventilated spaces, and observing social distancing when inside structures. General elections and mourning period of a previous President further delayed fieldwork in Zambia.

2.4. Ethics

Ethical approval to conduct this study was granted by Stellenbosch University Ethics Committee in South Africa (reference Number N20/10/115); University of Zambia Biomedical Research Ethics Committee (Reference Number 1393-2020) in Zambia, the London School of Hygiene and Tropical Medicine (LSHTM) Ethics Committee (Reference number 25789), and the University of Sheffield (Reference number 042825) in the United Kingdom. In Zambia, additional clearance, and permission to conduct the study was obtained from the National Health Research Authority (reference number NHRA00001/31/05/2021) and Lusaka City Council. Written voluntary informed consent was obtained from all study participants above the age of 18 years. Young people below the age of 18 years gave voluntary informed assent before participating in the study. Additionally, written informed consent was sought from parents or guardians of young people below 18 years old who participated in the study. Photographs of individuals that were recognizable in the photograph were only taken and stored if written informed consent was obtained. Permission was sought for taking photographs of infrastructure that would identify a place using an explanation that photographs would only be used to provide visual aid to illustrate research findings. Likewise, verbal consent was sought when conducting community observations at places of significance to WASH in the communities. We disseminated research findings to stakeholders at both community and national level. This familiarized research communities with our findings and also gave them an opportunity to validate and discuss the findings.

2.5. Building a community profile

Once the communities were selected, we started to develop a community profile ahead of fieldwork activities. We transferred some detail from our background research to a template structured around the four BBS meta-indicators more generally and more specifically related to water and sanitation infrastructure. This draft community profile was expanded upon during fieldwork. Fieldwork activities were listed in the profile (activity name, date, participant type and number). We also created a base map of the community, which outlined the boundaries, main roads, and physical features. To create the map, we used online maps (Google Maps/Earth) to navigate and view the community using Street View. We then copied the map from the internet into Microsoft PowerPoint where we started to draw the outline, boundaries, and main features using the Shapes feature in PowerPoint.

2.6. BBS fieldwork

The sequence of the BBS activities is summarized in Figure 1 and the number and type of activities, participants and supporting tools in Table 2. Once approval was granted from relevant institutions and relationships developed with ward councilors, we started planning for the first fieldwork activity, the WASH stakeholder's discussion in each community. For this discussion, we intended to invite participants who would be knowledgeable about

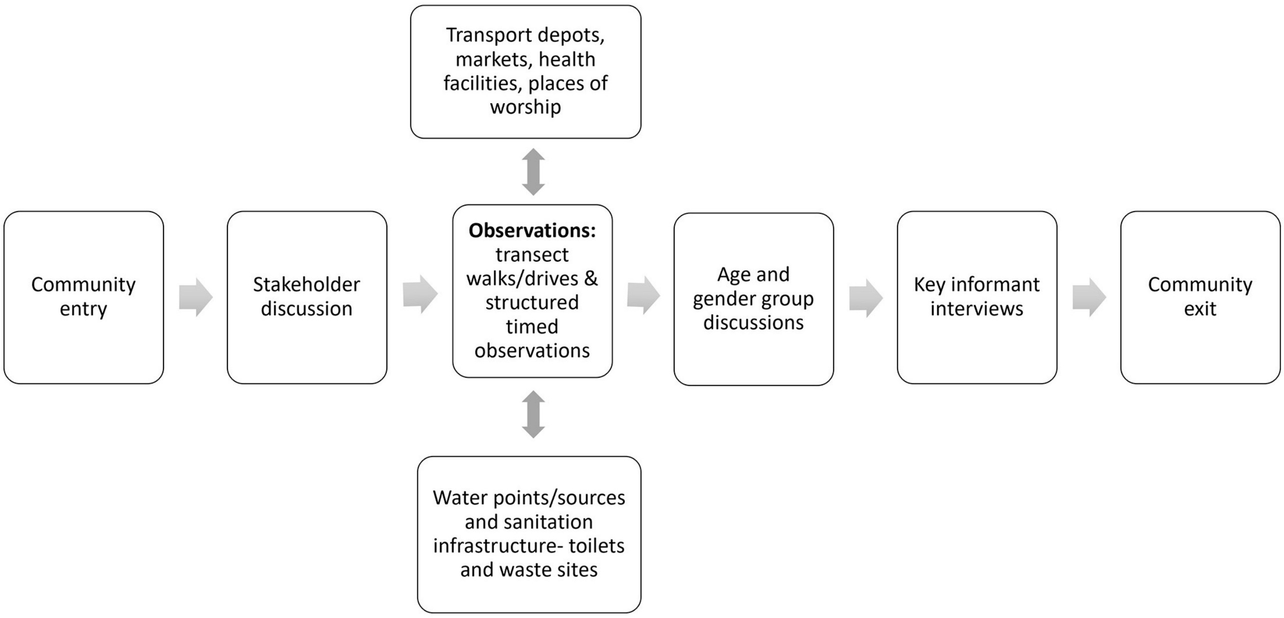

FIGURE 1
BBS sequence of activities.

WASH issues in the community and/or considered as leaders of the community. To mobilize participants for this discussion, we contacted potential participants telephonically (because of COVID-19), identified through contact lists or recommendations from local stakeholders. Most but not all potential participants were local community residents. The setting of the meeting had to be central or easily accessible for participants, and well-ventilated. This discussion centered around a mapping activity, where the boundaries of the community were discussed and verified, and places of relevance to WASH were located for the researchers to observe during the transect walk or drive, the second BBS activity.

The transect walk or drive was conducted immediately after the stakeholder discussion and on the following day. The large scale of geographic wards/communities and security issues in South Africa meant that this activity was primarily carried out by driving instead of walking. In Zambia, it was conducted by walking. The research pairs started walking or driving from a central point, stopping or getting out of the vehicle to observe the main features of the community, such as the types of housing, water and sanitation infrastructure, and people present. The researchers also visited water and sanitation infrastructure locations identified during the stakeholder discussion to observe the quality of the facility or infrastructure, take GPS coordinates and photographs, and make notes or sketches of the feature. In addition, places for structured time observations were noted down.

Structured timed observations were conducted as the next set of activities. The places of observation included key community facilities such as transport depots, markets, health facilities, places of worship, plus water and sanitation infrastructure locations (water points/sources, sanitation facilities including toilets and waste sites). Time was spent observing who is present at the locations, including the gender and age profiles of the population, and who was making use of different types of water and sanitation infrastructure. We had informal discussions with people at water and sanitation infrastructure observation locations to document their experiences.

The quality and usability of water and sanitation infrastructures and features were also observed through taking photographs and completing scorecards of the facilities. Aside from the set sequence of BBS qualitative activities, additional tools specific to the research issue can be added. We adapted and developed a water and sanitation checklist from the World Health Organization's (WHO) water/sanitary inspection package (WHO, 1997) (see Supplementary material 1). For each variable, the field researchers would observe what is present, classify the type of infrastructure, make descriptive notes about the structure/facility/source and its condition, ask more detailed questions to users about their challenges or preferences of facilities, and take photographs with the consent of users (if applicable). We then created a Likert scale from the checklist, with six parameters/themes, to score each water and sanitation facility based on their condition and suitability (infrastructure, location, access). For each infrastructure observed, we also derived an overall or total score, by summing up the individual ratings across the six parameters. The summation of parameter scores allowed us to assess and compare the holistic state of the observed water and sanitation facilities (Table 3).

Following the structured timed observations, focus group discussions (FGDs) were conducted with older groups of men and women and younger groups of men and women separately in community venues. The discussions focused on participant's experiences with water and sanitation infrastructure, WASH challenges, control of WASH resources, responsibility for services, and plausible solutions or recommendations for improved services and infrastructure planning. Through informal discussions during

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TABLE 2 BBS activities, participant details, and data collection tools.

Activity	Number of participants and representation		Activity length and time	Data collection guide
	Zambia	South Africa		
Stakeholder individual or group discussion	• One group discussion per community • 11 women; 9 men aged 29–77 years • Environmental health specialists (EHS), water trust, community-based enterprises (CBEs), market cooperatives and local leaders.	• One discussion per community • Four men, who are long-term residents and community leaders (i.e., ward councilors).	2–3 h; morning	Stakeholder discussion guide
Transect walk/drive	• Four transect walks in both Z1 and Z2 communities, one in the morning and another in the afternoon per community.	• Four transect drives in S3 and S4, for approximately 2 h per drive.	2–4 h for each observation	Transect walk guide, general observation checklist, activity report form, GPS tracking sheet
Structured observations: entry/exit points, transport depot and other places of relevance	• Eight entry/exit point observations in Z1 and Z2 communities (four in each community). • Observations at the main bus stop, along a busy footpath in Z1 and at a busy junction on a landmark boundary in Z2. • One clinic observation in each community • One weekend and night observation in each community	• Ten entry/exit point observations in S3 and S4 (multiple neighborhoods) • Observations conducted at a transport depot/taxi rank in S4.	15–60 min for each observation	Transport depot: observation guide, data capture sheet, structured observation activity report form, observations of the health facility activity report form
Group discussion with older people	• One group discussion per community • 21 women; 8 men aged 18–63 years • Community representatives from different sections	• One group discussion per community • 12 women; 7 men aged 39–80 years. • Residents, leaders/stakeholders (neighborhood watches, community engagement groups, NGOs/NPOs)	2–3 h; afternoon	Age, gender group discussion guide
Group discussion with young people	• One group discussion per community • 13 women; 9 men aged 15–17 years • Representatives from different community sections	• One "on the spot" group discussion in S4 • 12 young women and 4 young men, aged 17–38 years	2–3 h; afternoon	Age, gender group discussion guide
Structured observations: water and sanitation infrastructure (scorecard)	• Six water point/source observations in Z2 • Four sanitation infrastructure observations in Z1 and four in Z2. • 1 rain observation in each community	• Ten water point/source observations (8 in S3 and 2 in S4) • Seven sanitation infrastructure observations (5 in S3 and 2 in S4) • Activities of collecting water in containers, cleaning parks/dumping sites/portable toilets/washing clothes, stormwater drain overflows	15-30 min for each observation	Structured observation guide and water and sanitation observation scorecard
Key informant interviews	• 8 interviews in each community • 7 women; 9 men aged 29–72 years • Ward development committee representatives, CBEs, water vendors, EHSs, teachers, community and religious leaders, WASH service providers and WASH facility owners.	• 5 "on the spot" informal key informant discussions • 3 women and 2 men • Community leaders and a communal tap user.	1 to 1 ½ h	In-depth interview guide

TABLE 3 Water and sanitation scorecard parameters.

Parameters/themes	Score (0-very poor, 1-poor, 2-fair, 3-good, 4-very good)
1. Condition of water infrastructure/facility	
2. Physical condition of site	
3. Type of structure (temporary/permanent)	
4. Maintenance	
5. Availability/accessibility (public/private/shared)	
6. Location of facility relative to obvious sources of pollution	
Overall condition of facility (scale 0–25)	
(0–5-very poor, 6–10-poor, 11–15-fair, 16–20-good, 21–25-very good)	

the transect walks/drives and structured timed observations, we also recruited participants to take part in the gendered and age specific group discussions and key informant interviews. In Zambia, LFWs assisted with participant recruitment by approaching various individuals, households, and institutions in the communities. On the spot recruitment approaches in South Africa, meant that there were discrepancies with Zambian and South African age groups, especially with younger participants (15–30 years old). In Zambia, group discussions with young people were pre-arranged at venues. Whereas in South Africa, young people were approached on the street where they gathered, meaning that a wider range of young people participated.

The final BBS activities were key informant interviews (KIIs) conducted with knowledgeable individuals that had unique perspectives and experiences with water and sanitation infrastructure or service delivery. These individuals included prominent community leaders and community members that have lived in the community for a long time, residents or professionals who work or live in the community with adequate knowledge on and involvement in WASH. These interviews provided clarity and more details on issues that had been discussed during the FGDs.

Although this sequence of data collection was followed as described above, it was done slightly differently in both countries due to various implementation and institutional procedures. For example, in South Africa, data collection was conducted concurrently in the two study communities while in Zambia, data collection was first done in one community and written up, and then conducted in the next. In South Africa, some group discussions and interviews were conducted on the spot with participants. In both countries, during fieldwork, some days were spent away from the field to "build the picture" of each community, writing up the main findings in the community profile, writing up field notes, and adding meta-indicator layers to the community map (see findings and Supplementary material 2).

2.7. Rapid analysis

We rapidly analyzed data using a combined process of debriefing among field researchers, writing up the main findings from each data collection method into long community profiles of up to 20 pages, and plotting information on the community maps. These processes were done during and immediately after data collection took place. Short (four pages) and long community profiles were developed along with posters (A3) and maps (A0) including general and specific water and sanitation infrastructure findings for each meta-indicator.

2.8. Community and national level disseminations

The findings were first discussed with community stakeholders, including young people, WASH NGOs/non-profit organizations (NPOs), CBEs, community leaders/ward councilors, during half-day community dialogue meetings, aided by key messages developed from the findings (community and country specific) (Simwinga et al., 2016). Findings were presented using PowerPoint, pictures, community profile posters and maps. Community stakeholders reflected on the meaning and implications of the findings, and next steps. This process also allowed for researchers to verify that the information accurately represents the different perspectives in the communities. The findings were then shared at national/provincial levels, with community members present, where discussions included solutions to address WASH challenges.

2.9. Challenges in operationalizing BBS for water and sanitation

Security was a major challenge in both countries. In South African settings, safety concerns arose due to being in an unfamiliar, high-crime context. To address this, a driver familiar with the areas accompanied the researchers. These drives were included in the data collection, by pragmatically adapting the transect walk into a transect drive. In the Zambian setting, safety concerns triggered by a certain neighborhood in one community where there were alleged to be clandestine activities, and by political tensions surrounding a general election. The Zambian team addressed these concerns by avoiding either the identified neighborhood, and pulling out the field for a period, and always being accompanied in the field by a local fieldworker.

Obtaining research permission from political authorities was a new requirement for this study, unlike previous ones that only required approval from health authorities. Identifying suitable communities through background research led to consultations with political authorities, such as ward councilors, for permission. In some instances, access was denied when no direct financial opportunities for the community were apparent, necessitating further research for suitable communities. Busy schedules of political authorities posed challenges, but most agreed to the research recognizing its importance in understanding water and sanitation issues.

Recruiting participants for group discussions proved more challenging in South Africa compared to Zambia, where some informal on-the-spot group discussions were employed that provided a general sense of community perspectives. However, forming coherent groups was difficult due to the non-formal setting, though participants expressed themselves more comfortably and open. Data collection faced delays and challenges, and additional buffer time was necessary in the planning process. COVID cases in South Africa led to cancellations of fieldwork, while in Zambia, staff falling ill and general elections caused postponements.

Analyzing data using the meta-indicators framework proved challenging for new researchers, particularly distinguishing social organization from social networks. Collaborative efforts with teams from both countries included reflective and debriefing sessions during fieldwork and write-up to ensure the findings were structured and organized accurately.

3. Findings

We first present our water and sanitation infrastructure findings using the meta-indicators framework, moving from physical features to social organization then social networks, and finally community narratives. In each of the four meta-indicator tables, in the latter order, and for each community, we first present a summary of the meta-indicator in general and then specific detail on water and sanitation infrastructure in the four selected communities. Refer to the anonymized map of Z2 in Supplementary material 2, which visually illustrates the findings along the four meta-indicators. Linked to each of the four meta-indicator descriptions, we depict the relationship between the meta-indicator and water and sanitation infrastructure across the two South African communities and then the two Zambian communities, before drawing out patterns across the four communities and two countries. After presenting each meta-indicator in turn, we show and reflect on which BBS research activities led to what findings about water and sanitation. Finally, we draw on the water score card, an additional observation tool we added to this BBS, to demonstrate findings on water and sanitation from this adapted research tool.

3.1. Community descriptions along the meta-indicators

3.1.1. Physical features—what are the physical/visible features of the general community and water and sanitation services?

See Table 4 for physical features and related water and sanitation infrastructure community detail.

3.1.1.1. S3 and S4 physical features and water and sanitation infrastructure

Both S3 and S4 exhibit socioeconomic and racial divisions, mainly along rivers and major roads. The middle-higher income areas have better access to formal water and sanitation options compared to the lower-middle income areas. In S3, both established and new informal settlements exist, with various water options available such as outside yard standpipes, communal standpipes, metered water kiosks, serviced plots, and portable toilets. In S4, formalized RDP housing areas coexist with backyard housing, resulting in more shared flush and tap facilities within yards or houses.

Both communities are located in peri-urban areas on the outskirts of Cape Town, where agricultural land is prevalent. Subsistence farming is practiced in these areas, alongside informal housing and a lack of WASH services. Residents and farmers in these areas rely on a limited number of water standpipes or water trucks provided by the government. In S3, there are illegal pipe connections to households in a farming community where communal standpipes are the only available water source.

Lower-middle income neighborhoods, including informal settlements and a mix of RDP housing and privately-built housing areas, have significant waste dumping sites in both S3 and S4. These sites are often found in open spaces, wetlands, and along canals/rivers. Waste is indiscriminately dumped, leading to stagnant water and blockages in stormwater drains, causing road overflows. Sewer blockages from waste are most prevalent in two S4 neighborhoods with a mix of RDP housing and backyard housing. In one farming neighborhood of S3, there are massive waste heaps upon entering the area. Adjacent to another subsistence farming community in S3, a canal connected to the river is polluted with solid waste, human waste, and sewage.

3.1.1.2. Z1 and Z2 physical features and water and sanitation infrastructure

Z1 and Z2 are socio-economically diverse and ethnically mixed, with planned and unplanned neighborhoods reflecting respectively middle- and lower-income social groups. Lower-income areas in both communities receive water from public service providers through kiosks and a few standpipes household connections. There are more informal and cheaper sources of water accessed by lower-income groups; in Z2, residents take advantage of water leakages from public infrastructure, and in Z1, residents use shallow wells (that are deemed illegal) and water from a large drainage with running water and a stream located within the community. Accessing water amongst the middle-income groups in the two communities differs. In Z1, the middle-income areas have water supplied to private taps in households through a public reticulation system and sewer system. Whereas in Z2, the middle-income areas largely rely on private and institutional boreholes to supply water to individual households, along with collecting water from communal public water points. Only the middle-income area in Z1 has flushable toilets and is mainly serviced by a public sewer system; groups in all other areas rely on on-site sanitation options. However, the type of toilets differ across socio-economic groups with the low-income groups in Z1 and Z2 using pit-latrines (traditional, ventilated), and the middle-income group in Z2 mainly

TABLE 4 Physical features—General and specific to water and sanitation in four communities.

Community	General physical features	Water and sanitation description
Z1	Z1 is located north of Lusaka; bounded by two main roads on the west and south, a stream on the north and a railway line on the east. It shares boundaries with four other communities. It is predominantly an informal settlement (small and clustered housing structures and unplanned roads) and a small section of the community with larger housing structures and commercial premises near a main road. Key amenities include three markets; one health facility and an NGO anti-retroviral clinic; two government, one community and several private schools. Additionally, there is a police post, the municipal council, TWT, offices for the main electricity supply company, and a filling station.	The Water Trust (TWT) (a community initiative pioneered by an international NGO) has four boreholes supplying water to the community through 69 communal water points (kiosks) and 450 household connections. Three private boreholes (two belonging to churches and one by the Islamic society) supplement water provision for free for residents. A large drainage constructed by a donor funded project to reduce flooding has running water from various sources. The stream on the north and the drainage have polluted water (either sewer waste, industrial effluent or solid waste disposed). Toilet options include pit latrines, flushable toilets in few community sections and five communal toilets. However, not all households have toilets leading to residents defecating in plastic bags or cartons, called "flying toilets".
Z2	Z2 is located south of Lusaka. It is a developing community with four distinct neighborhoods and is surrounded by other communities. Due to its developing nature, defining clear-cut boundaries is challenging even for residents. It is bound by a railway line on the west, extends into farmlands on the south, leads into other communities on the east and north. The southern part of the community is sparsely populated (houses sparsely distributed and large, with modern designs and beautiful landscapes) whereas the northern part (initial settlement) is densely populated with relatively older and smaller clustered housing structures that mostly have outdoor toilets. The community has two markets, a health post, two government, several community/private schools, lodges, churches, and a filling station.	The Lusaka Water Supply and Sanitation Company (LWSC) has two production boreholes in the community - one at the council office drilled by an international NGO and another at shaft five located to the south of the community. Water infrastructure run by LWSC includes a suspended tank, communal water points (kiosks) and private taps. There is one communal borehole at the main market and several drilled on private property by residents (predominantly in new settlement areas with sparsely distributed houses). Toilet options include flushable, pour flush and traditional pit-latrines. Environmentally friendly pit-latrines (with a fully lined substructure that can be emptied) were recently introduced through the Lusaka sanitation program. There are a few households without toilets. Push carts are used to collect and dispose of solid waste.
S3	Located east of Cape Town, adjacent to agricultural land, S3 has nearly 24 clustered neighborhoods stratified socially and economically into lower-income and lower-middle-income areas and divided by major roads. S3 has serviced informal settlements and newly constructed unserviced informal settlements, a major township and subsistance farmlands. Housing options include reconstruction and development program (RDP) government housing and privately-owned housing. A major river passes through the community.	Formal housing areas to the east have access to piped water and indoor flush toilets. A subsistence farming community south have no access to toilets and water except 3–4 water taps installed by the government. Access to water and toilet facilities vary on the west in the township and adjacent informal settlements, ranging from indoor flush toilets (RDP and privately built houses), portable toilets, outside metered water kiosks, water standpipes, communal flush toilets/taps (informal settlements), and government provided plots with concrete flush toilets and a metered water basin (serviced plots).
S4	S4 is located in the Cape Town metropole, to the east surrounded by major roads and some open agricultural land. It has 10 neighborhoods clustered as a political ward. A major river runs through S4, dividing the lower-income and middle-higher income areas. Housing options include a mix of formal privately owned houses, townhouse complexes, RDP housing and widespread backyard informal housing.	Access is provided to all communities in the form of piped water and indoor flush toilets. However, access is not equally distributed (lack of equal distribution is particularly seen RDP areas on the west). These RDP settlements are particularly prone to flooding and blocked drains, as a consequence located close to the river. Some houses in middle-higher income neighborhoods to the east use borehole water as well.

using flushable or pour flush toilet facilities that use septic and soak-away systems. In Z1, the use of "flying toilets" (defecation in plastic bags or paper cartons) was reported.

Solid waste disposal is a challenge in both communities. There are no designated waste disposal areas in the two communities. The challenges of solid waste disposal are worse in the unplanned neighborhoods that are densely populated compared to the planned neighborhoods. Challenges with solid waste disposal in the densely populated areas can partly be attributed to lack of access to roads for solid waste management companies. The community boundaries (in or along the stream, drainage, and railway line in Z1) and along the railway line in Z2 are the places where solid waste is disposed. Other places where solid waste is disposed include open spaces along the roads and in drainages in both communities. In Z2, solid waste is also disposed in unoccupied buildings that are under construction, near a football field, and some residents dig pits for waste disposal. Clogged drainages are common due to improper waste disposal in both communities.

3.1.1.3. Cross-country comparison of physical features and water and sanitation infrastructure

In all four communities, the formal water supply systems were insufficient to meet the demand as governments struggled to expand service delivery. Compared to South Africa, the Zambian communities had fewer households supplied with piped water using a reticulation system. Drawing water from cheaper or free sources was common practice amongst lower-income groups, and included damaged public infrastructure. Indeed, damaged water infrastructure was visible in all communities. Likewise, new toilet designs were evident in lower-income areas, with many also having maintenance challenges, for example, emptying sludge. In all four communities, flush toilets of varied design were usually located within houses and sometimes outside in a separate building. The flushing system was not always functional due to poor water supply systems or damaged flush parts, forcing residents to pour water to flush the toilets.

Disposal of sewage sludge was a challenge and a health risk in all study communities. Open areas and water courses provide space for dumping, but dumping also occurred in cramped spaces. There were clear inequities in access or ability to access water and toilets across middle- and lower-income groups in all four communities. Although lower-income areas were more impacted by dumping, open space could also be located near to or in middle-income areas, and solid-waste disposal challenges were apparent across all groups.

3.1.2. Social organization—what are the relations of people to this place?

Table 5 convey the social organization features and the water and sanitation infrastructure in the selected communities.

3.1.2.1. S3 and S4 social organization and water and sanitation infrastructure

In both S3 and S4, lower-income areas face challenges sharing facilities and infrastructure due to dense populations. The portable toilets provided by an outsourced/tendered company are maintained by employed workers, mainly local residents who are women. In S4′s low-middle income neighborhoods with backyard housing, indoor and yard water/sanitation facilities are shared, straining infrastructure designed for one household per plot. Water is metered by water management devices in lower-middle income areas in both S3 and S4, affecting daily water accessibility and driving a practice to access free water elsewhere. In S3′s farming area, neighboring residents collect water from limited communal taps to save costs on private usage. In the other farming area, water is collected from nearby informal settlements with communal facilities. Furthermore, unplanned informal settlements in S3 face water scarcity, leading residents to collect water from those with private serviced plots nearby. Government-led efforts in both S3 and S4 involve employing community members through the Expanded Public Works Programme (EPWP) for short-term employment in waste clearing.

3.1.2.2. Z1 and Z2 social organization and water and sanitation infrastructure

Z1 and Z2 have distinct water service providers, the Water Trust (TWT) and Lusaka water supply and sanitation company (LWSC), supplying water through communal water points (kiosks) and household connections. Local residents are employed at kiosks. In Z1, both planned and unplanned neighborhoods receive water from TWT, while in Z2, LWSC mainly supplies the unplanned neighborhood. Religious organizations operate three boreholes in Z1, providing free water, while a religious organization charges for water in Z2. There is an informal economy of some institutions (for example a garage in Z1) and households charging to share public service water, and alternative water sources (for example shallow wells in Z1).

Solid waste collection and disposal are managed by community-based enterprises (CBEs) in both communities. However, the CBEs struggle with collection of solid waste due to lack of resources (transport, financial and human), attributed mainly to residents failing to pay for solid waste collection. As a result, residents dispose solid waste in undesignated spaces in the community and engage illegal dumpers who charge less and perpetuate the problem of indiscriminate waste disposal. In Z1, the CBE collaborates with TWT in solid waste management through the bundling system (for every $2.60 paid for water, 52 cents is for solid waste management). The CBE in Z2 has a robust solid waste management system at the dumpsite where primary and secondary sorting of solid waste is conducted for the purpose of recycling.

Densely populated low-income areas in both communities share toilet facilities and agree on cleaning duties or a fee. In Z1, manual desludging of filled up toilets by residents is common. Both communities have benefitted from developmental projects aimed at improving sanitation facilities. In Z2, LWSC through the Lusaka sanitation program benefitted from the construction of subsidized VIP pit latrines with a fully lined substructure while in Z1 pivot toilets with a septic tank that separated urine and fecal matter for recycling purposes (fertilizer production) had been introduced.

3.1.2.3. Cross-country comparison of social organization and water and sanitation infrastructure

There is a mix of public delivery of water that is metered across all communities and some commercial delivery of water in South African communities, paid for by municipalities. Institutions and commercial premises in Zambian communities, and households

TABLE 5 Social organization - general and specific to water and sanitation in four communities.

Community	Social organization–general community	Social organization–water and sanitation
Z1	Low-income areas are densely clustered compared to the middle-high income areas. Residents settle near their livelihoods. Minority racial groups (Somalis and Indians) have settled near wholesale premises where they trade, while local traders have settled near markets. Residents in formal employment and others conducting businesses outside the community commute either by foot, mini-buses, or bicycles. Charcoal traders are the identifiable transient populations at one market. Public service providers include a health facility, police, and TWT.	TWT controls access to potable water through kiosks (US$2,59 per 20ℓ container) and household connections (billed monthly via a meter). Water vendors regulate kiosk access and maintenance. The drainage, stream, and shallow wells serve as alternative water sources. Shallow well water is accessed for free or at a minimal charge per month. Water from the drainage and stream is free. Communal toilets help improve sanitation and generate revenue for TWT and market cooperatives. Three community-based enterprises (CBEs) collaborate with TWT in solid waste management through the bundling system (for every US$2,59 paid for water, 50 cents is for solid waste management).
Z2	Z2 has diverse Zambian ethnic groups. The sparsely populated middle-high income areas offer expensive housing. The densely populated initial settlement houses mainly low-income residents. Residents from middle-high income areas are mostly in formal employment, while the lower-income settlement residents mainly engage in market trading and small businesses. Mobility is routine, with residents leaving and re-entering the community for school and different livelihood options, often busier in the morning and evening. Seasonal mobility is linked to farming.	In the low-income settlement, households connected to LWSC have personal standpipes with fixed or metered monthly bills. Water vendors at kiosks charge 10c/20ℓ container, and some kiosks originally designed with a token system have been replaced with taps. Private boreholes are used by some residents and a market cooperative manages a communal borehole for traders and residents. The community uses on-site sanitation. Solid waste is either burnt, dumped in pits at households, kept in bins (awaiting collection) or dumped in illegal dumpsites. A CBE charges US$2, 54–$3,57 to collect solid waste using push carts and a truck, transporting it along the railway line to a dumpsite. At the dumpsite, primary and secondary waste segregation occurs before disposing of non-recyclable waste.
S3	Most residents are colored[a] (in the east), living in private and RDP housing. Black Xhosa and African foreign nationals live in formal and informal housing to the west. Colored neighborhoods have multi-generational houses, while the informal settlements have younger populations. Christianity is the predominant religion. Subsistence farming areas are occupied by foreign nationals employed by landowners, some living here despite having formal housing nearby. Informal employment (vendors, tuckshops, shebeens, small-scale farming) is prevalent in the west, while the east is dominated by formal employment (shopping malls, industrial areas). Minibus taxis are the main mode of transport, mainly used by women commuting to retail or domestic work.	Residents with private homes (east) are charged for water usage and the more people/houses per plot, the higher the water bills. Whereas RDP houses have water meter restrictions of around 350ℓ per day. Residents with serviced plots in informal settlements have limited metered water at ∼130ℓ per household daily, compared to other households limited to 100ℓ per blue metered kiosks, and 20ℓ, 8 times a day for outside standpipes. Newly constructed informal settlements have no access to water and toilets and resort to open defecation and walking long distances to access a standpipe. Residents from unplanned farms to the south-east only have access to 1 functional communal standpipe. The government also provide water bowsers to the farm areas daily. Farm residents also collect recyclable materials that are scattered on the farms to sell to companies outside for an income.
S4	The majority of residents are colored, followed by black Xhosa and African foreign nationals. The north-eastern areas have white and colored residents representing middle to higher-income groups. Backyard housing is prevalent in the west with a younger population. Christian and Islamic religious institutes are dominant. Industrial areas and agricultural spaces provide job opportunities, and residents often commute outside for work. Middle-higher income areas access private car transport, while minibus taxis are used in the west.	Government-employed waste collectors/street cleaners are mostly local residents. Water and sanitation services are generally determined by where individuals are located in the north-west, with some sections or streets having only outside flush toilets and taps; the rest have indoor toilets and taps, shared by multiple households. Similarly, south-west residents in backyard housing are dependent on main houses for these services, leading to overuse of facilities. High reports of illegal dumping of waste near the river and wetlands.

[a]The term "coloured" refers to racially mixed or "people of colour". Despite the end of apartheid, race still significantly impact the lives of most South Africans, remaining a prominent model for social organisation and identity (Finchilescu and Tredoux, 2010).

in all communities, will sometimes raise funds by selling metered water they have paid or borehole water to other residents. NGOs and religious organizations play a key role in the implementation of water and sanitation interventions. Dumping of solid waste in South African communities was organized by outsiders, whereas in Zambian communities, the illegal dumpers were local residents. Water, sanitation and solid waste management run by public and private bodies and households creates both formal and informal employment and/or raises income for both men and women, although in Zambian communities, most of these opportunities were for men.

3.1.3. Social networks—what are the relations of people to people in this place?

Table 6 convey the social network and linked water and sanitation detail in the community.

3.1.3.1. S3 and S4 social networks and water and sanitation infrastructure

Economic difficulties lead main house owners to rent out backyard space in S4, mainly to foreigners at around \$19 per month. Approximately 4–6 backyard households share water and sanitation facilities in one main house or yard. In S3, the rise in new informal settlements is driven by economic opportunities in the city. In informal settlements and farming areas, residents with better access to water often share communal water taps with those who lack access. High demand from population growth leads to more households sharing limited facilities, and newly settled residents access water from neighboring areas.

In S3, communal toilet blockages take up to 4 days to be fixed, leading some to assign specific houses for toilet use, locked with padlocks. In S4, multiple households sharing one toilet often face regular breakages, with lengthy waiting times for repairs or being asked by the municipality to hire a plumber themselves. Sharing households are all responsible to clean after themselves and use gray water or containers to flush when the toilet is broken. In S4, EPWP-employed workers clear waste daily from an open space, while young residents collect waste near dumping sites to protect children playing. A Rastafarian leader in S3 actively encourages cleanliness, especially around his vegetable plot and crèche. Residents generate income by selling recyclables to outside companies through waste picking on farms.

3.1.3.2. Z1 and Z2 social networks and water and sanitation infrastructure

In both Z1 and Z2, networks revolve around sharing of water sources, water collection containers and the means of collecting water. Residents in both communities form networks through collection of water from communal water points. In Z2, sharing or hiring containers for drawing water (drums) and pushing drums at a fee has created networks among residents. In Z1, other networks emanate from sharing alternative water sources such as the shallow water wells, scoop wells, drainage, and the stream. In Z2, residents with private boreholes have created networks with those that do not have by supplying water to them at a fee.

In both communities, sharing of toilet facilities (influenced by lack of toilet structures, proximity of households and interpersonal relationships) has created networks among community members who agree on the terms of toilet sharing. In Z1, networks are formed among residents who own toilets and those who offer manual desludging services for filled up toilets. In both communities, networks also exist among residents and illegal waste collectors who offer cheaper solid waste disposal services in the communities. In Z2, residents have also formed networks with individuals who dig solid waste pits within their premises. The CBEs in both communities foster networks by employing residents to collect solid waste. In Z2, the CBE further created networks among casual workers who sort and segregate solid waste into types, solid waste aggregators who bring empty bottles and plastics to exchange for money and manufacturing companies who buy recyclable waste.

3.1.3.3. Cross-country comparison of social networks and water and sanitation infrastructure

Employment networks are linked to water, sanitation and solid waste management in all the four communities; with employment being both casual and formal, and employers being public service organizations and private enterprises or individuals. Sharing toilet facilities is common across all communities and is not always an economic transaction. Networks across community/neighborhood boundaries and income groups are formed in the process of accessing water. There are some striking examples of community action in response to solid waste management in the South African communities.

3.1.4. Community narratives—what do people say about this place?

Table 7 summarize the community narrative and linked water and sanitation infrastructure community detail.

3.1.4.1. S3 and S4 narratives and water and sanitation infrastructure

Narratives convey that S3 and S4 communities voice their experience in housing, water, and sanitation services including residents waiting for proper housing and basic services, and inadequate infrastructure, leading to water cuts, low pressure, and overflow problems. In S3, residents focused on how water availability is strained by people from other areas collecting water in serviced settlements, while in S4, increased population sharing limited water resources was voiced:

> "*The challenge is that people from other areas come and collect water from here. People do not follow the rules. For example, they put the bucket on top of the tap, and then the tap breaks*". (S3, Stakeholder discussion).
>
> "*We receive 350 liters of water with 5 households living on the yard. One hour later the water is cut, then we have to use washing water for the toilet (gray water). We have to inform everyone on the yard when you will do your washing*". (S4, young FGD)

Additionally, in S3, some residents explained how they still use buckets for defecation due to the lack of planned services in certain areas, while in S4, poor sewerage drains and pipes was said to lead to sewage overflow:

TABLE 6 Social networks—general and specific to water and sanitation in four communities.

Community	Social networks—general community	Social networks—water and sanitation
Z1	Z1 Health center and the NGO ART clinic foster networks by offering healthcare services and opportunities for voluntary work to residents and outsiders. Trading networks form as residents buy, sell goods, and share trading spaces in wholesale shops and markets. Wholesale businesses provide employment connections and foster relationships across minority racial groups like Indians, Somalis, Rwandese, and local residents. Somali and Indian residents bond through a common belief in Islam, while other residents meet at respective churches. Networks are formed through shared interests at bars, lodges, salons, barbershops, and playing football.	TWT creates an extensive network through community water vendors, communal toilets and their custodians as well as the CBEs. Likewise, sharing of water from water wells creates a network between users. Sharing toilets among households that have toilets and those that do not have creates networks, influenced by proximity, interpersonal relationships, and the responsibility of maintaining toilets. Other networks are developed from manual desludging services offered by residents who use buckets to empty filled-up pit-latrines.
Z2	Residents in the low-density areas are connected through employment such as car wash businesses, farming, and the presence of shops. Similarly, residents in the high-density area have formed networks through trading at the market, common interests, and shared religious values.	In the low-density area, residents form relationships by sharing water from boreholes. Those without boreholes connect pipes to households from individuals or institutions (church, clinic) for a fee or draw water in drums or 20ℓ containers. Water drums are also shared/hired for collecting water. Adolescents/young people and women push water drums from water points to households to earn money. Toilet sharing is common, influenced by proximity, relationship, lack of facilities. Solid waste management networks include, casual workers who sort solid waste, solid waste aggregators who exchange empty bottles and plastics for money, manufacturing companies who buy recyclable waste. Some residents engage unauthorized "dumpers" to collect and dispose solid waste in undesignated spaces at negotiable fees (US$1,29-$2,33) or dig garbage pits within their premises.
S3	S3 is characterized by intertwined township & informal settlement areas with blurred boundaries. Residents are connected through migrant status and ties to the Eastern Cape, fostering extensive communal support for informal businesses. The predominantly colored area, where multiple generations live together, has newly developed RDP housing primarily provided to outsiders. In this area, the neighborhood watch ("the walking bus,") consisting mostly of elderly women, plays a significant role in keeping the youth away from gangs.	Informal settlements with higher water restrictions received uncontrolled standpipes; serviced plot residents complain of visitors from the decanting site collecting water. Farmers near serviced settlements access communal taps, leading to breaks due to high demand. South-east farm residents accuse wealthier neighbors of collecting multiple containers of water from working communal standpipes and attribute theft and tap damage to drug users. Open defecation occurs in farm areas and new informal settlements without sanitation infrastructure. Temporary settlements use more maintained portable toilets instead of communal flush toilets. Some residents implemented a system to assign households to specific communal toilets controlled by a padlock.
S4	S4 faces challenges, with one neighborhood divided among rival gangs, making it difficult for residents to move around safely and police patrols are evident. Elderly individuals have better connections with gangs and can negotiate safe passage. Gang recruitment of young people for drug sales is common. Another low-income neighborhood shares a boundary with a more affluent sub-area where residents prefer not to mix. Service delivery is further constrained by gang territories.	In addition to EPWP workers, concerned citizens proactively pick up waste daily despite ongoing waste dumping in the north-east area. Younger residents living near the dumping site collect waste to prevent drain blockages, directly impacting their health and the health of their children. Residents south-west face challenges with their drainage systems due to close proximity to wetlands and the river. RDP houses, and title deeds, were provided to residents providing they sustained maintenance. To address blocked drains and sewage-filled streets, residents lodge complaints with the local municipality.

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TABLE 7 Social narratives—general and specific to water and sanitation in four communities.

Community	Narratives—general community	Narratives—water and sanitation
Z1	Z1 emerged as an informal settlement in 1957 with illegal settlers building mud houses along the periphery of a farm that was owned by a white couple. After independence, the city council was mandated to provide services. However, public service provision has only been improved in the last 20 years. Poverty and crime were identified as community challenges.	Originally, people accessed water through public taps. In 2002, an international NGO established TWT to address water and sanitation challenges in the unplanned settlement. Limited space made constructing new toilets & communal water points a challenge. In 2003, pivot toilets with septic tanks for removal of recyclable sludge to produce fertilizer were introduced but proved unviable. Residents use TWT's water for drinking and alternative water sources for other uses to reduce bills. TWT provides free water to bereaved families during funerals. Use of shallow wells is secretive given the local authorities' efforts to ban their use. Some residents feel neglected by the government due to poor service provision.
Z2	Residents have different stories about the origin of the name of the community but have consensus that it was attributed to the development that transpired in the community. The first settlers lived in the densely populated area of the community, reputably a farm that was owned by a Boer farmer. The whole community has been growing over time and sub-communities emerged.	Historically accessing water has been a challenge as the council's supply was insufficient for the whole community. In 2013, LWSC started supplying water and in 2015, the utility company received a grant to drill a borehole, set up kiosks, &repair dilapidated water systems. However, on-site contamination of underground water, threatens ground water quality: one borehole funded by the grant was abandoned. Some areas offer "free water" through old kiosks with the token system removed. A community volunteer oversees this water point where residents fetch unrestricted water and pay US$1,02 for damage maintenance. Residents are informed on prevention measures during water-borne disease outbreaks.
S3	The Township originated as a hostel for black laborers during apartheid & has now become densely populated with new informal settlements. The rise of informal settlements is linked to the negative economic impacts of COVID-19. Clashes between the government and settlers occur when houses are demolished due to the lack of planned services. Plans to construct 2,500 homes on the south-east farms, currently occupied by long-term residents, have sparked requests for better services where they currently reside. In the north-east predominantly colored area, pervasive gangsterism contributes to crime in open spaces.	Circa 10 years ago, some informal settlements in the township acquired flush toilets and standpipes. However, the township faces water cuts lasting up to 6 h on weekends, with low pressure upon its return. Water scarcity is exacerbated by people from other areas collecting water, leading to broken taps. The serviced area is on dry land, while other informal settlements are flood-prone, resulting in prioritized serviced plots for some settlements. Serviced areas still experience drain overflows during the rainy season. COVID-19 has further delayed water and sanitation service delivery. The older colored-majority area experiences pressure on drains due to new housing constructions. Backyard residents with private toilets mention that others see these homes as temporary and lack the means to install their own toilets and taps. Farm residents claim neglect by local authorities (only water standpipes installed despite promised housing in 2018).
S4	In the south-west RDP area established in the late 1990s, bribery for housing allocations (US$390) by government officials was reported. Residents attribute challenges in housing, education gaps, psychological services, and water to the government. Gangsterism is associated with economic opportunities for school dropouts, and restricts access to services, worsening social ills. In the north-west RDP area, residents strongly express discontent about overpopulation, linking it to corruption and job losses during the COVID-19 pandemic. Limited opportunities in create a sense of hopelessness.	Residents face stormwater overflow and flooding in their houses due to substandard construction of sewerage drains and pipes in the south-west. Health risks are associated with the polluted rivers, wetlands, and drains, believed to contribute to cancer & TB for some residents. Frequent drain blockages cause unsanitary smells in the north-west. Roads are poorly maintained, with potholes filled with stagnant water. Younger residents blame foreign nationals for wasting water and resources.

> "*People defecate in open areas or buckets. It is unsanitary since some younger residents knock over the feces.*" (S3, informal KII)
>
> "*The houses share water and sewerage pipes. When the pipes are blocked at one house, it causes an overflow at another house. We cannot plan or build anything on our plots because of the poor design of pipes underneath.*" (S4, older FGD)

Both communities were acutely aware of facing service delivery inequalities, with certain areas being identified as receiving more attention and resources. In S4, wealthier neighborhoods to the east were pointed out by the informal settlement residents as having better infrastructure design to maintain the river flow. Whereas in S3, farm residents feel neglected by local authorities, as housing promises made only resulted in water standpipes being installed in 2017. Limited access resulted in broken or occupied communal standpipes.

> "*When it rains you cannot cross the river because it overflows. For people living higher up the river, the canals are built higher which prevents overflow. Over here, the river is not being maintained.*" (S4, young FGD)
>
> "*In 2017 water standpipes were established when new pipes were laid underground. Some of the people stole the pipes underneath the ground and then the water pressure dropped completely because they connected their own pipes. A water valve was installed that only allows a certain percentage of pressure for water to come through.*" (S3, Stakeholder discussion)
>
> "'*White' (privileged) people fill up containers full of water so that they don't have to pay for water at their homes.*" (S3, Informal KII)

The influx of people affects housing availability and maintenance in both communities, with some blaming outsiders who move into new RDP housing, political sabotage of service delivery and foreign nationals for resource waste:

> "*We never used to have problems with drainage, only when they started to build new houses over there in [sub-neighborhood of S3]*". (S3, older FGD)
>
> "*Today you will clean, tomorrow there's new waste that were dumped. All this dumping is about political control because there is currently a battle about controlling the ward. Political rivals try to gain points from people when they clean spaces, hence the dumping occurs*". (S3, older FGD).
>
> "*The foreigners can waste water. They do their washing and cook the entire day. They have more water than us. They live all over.*" (S4, young FGD)

3.1.4.2. Z1 and Z2 narratives and water and sanitation infrastructure

Both Z1 and Z2 shared their history of emerging as unplanned settlements from farms and their historical challenges with water and sanitation services. The main water service provider was reported to not be able to meet the demand of the rapidly growing population in both communities.

> *"…..there are still areas that are not serviced because these peri-urban areas expand every day and the rate of urbanization is expanding is not matching service delivery". (Z2_KII)*

In both communities, residents from low-income houses shared their challenges in meeting the cost of water.

> *"Lack of money is a challenge for people to access water and sanitation because some people cannot afford to connect pipes in order to have standpipes and others cannot afford to pay at the water points". (Z2_KII)*

This pushes them to resort to alternative and unsafe sources of water – shallow wells, water from the drainage and stream in Z1, and water from leaking pipes in Z2. In both communities, the use of alternative sources of water is secretive as it is illegal. Some community members in Z1 justified the use of alternative sources of water, saying, *"water does not kill,"* hence they could use the alternative sources of water without anticipating any challenges.

> *"Someone would say I have been here for years, drinking this water and am here, am good, what can you tell me". (Z1, KII)*
>
> *"As long as there is intermittent supply of water, people will always resort to shallow wells". (Z1, KII)*

Abandonment of water sources due to a risk of ground water contamination was narrated linked to public service boreholes in both communities and private boreholes in Z2. Residents in Z2 also pointed out that privately owned boreholes are considered unsafe due to lack of testing for impurities.

In both communities residents expressed dissatisfaction with the CBEs for not being able to collect solid waste, and in Z1, the bundling system was reported as not able to working effectively.

> *"The challenge with garbage collection was that most people did not want to pay money for their garbage to be collected but would still take their garbage to the pick-up points". (Z1, KII)*

The lack of toilets in Z1 was linked to the lack of space to construct toilets due to over population and limited resources among some residents who could not afford to construct toilets, which sometimes led to defecating in the open or plastic bags.

> *"At home, most people use personal pit latrines and those that do not have toilets use their neighbors if they talk to them or have some sort of friendship". (Z1_Young FGD)*
>
> *"When someone has diarrhea, they have to ask from those with toilets. It is common to find people have defecated in plastics or by the corner of building that is less busy….some people also use the stream as a toilet and defecate in the open or while others go there to throw human feces". (Z1_KII)*

Although both communities have had developmental projects aimed at improving the supply of water and sanitation, development initiatives are sometimes reported to have been unsuccessful. For example, in Z2, the newly introduced subsidized environmentally friendly pit-latrines (with a fully lined substructure that can be emptied) through a donor funded program have been received with skepticism by some residents who consider them likely to fill up quickly compared to the ordinary pit latrines.

3.1.4.3. Cross-country comparison of community narratives and water and sanitation infrastructure

In all four communities, local residents voice their frustrations and lack of dignity and a feeling of neglect in the face of limited water, sanitation and solid waste infrastructure. In South Africa and Z1 in Zambia, local residents tended to blame the government or outsiders. Overall, there is a stronger reliance on the government to "fix" things in South African communities, as opposed to Zambian communities being more self-sufficient. In both Zambian communities and S3 in South Africa, local residents also blamed better off residents for exploiting worse off residents through a pattern of re-selling water. All communities were eager for interventions to improve their water and sanitation infrastructure and solid waste management.

3.2. Data sources for water and sanitation options

Table 8 reflects the data sources for the different water and sanitation options in each of the four communities. This over-view of data sources reflects the importance of having a mix of qualitative methods—observations, group discussions, key informant-interviews. It also illustrates as the value of particular participatory techniques, particularly mapping, and of adding new tools to the core set of BBS research tools since the water score card is often a data source. Moreover, the table reflects how information on the specific infrastructure emerged in the sequence of the BBS approach, with most being informed by a combination of methods. We use two examples from Zambia and South Africa to illustrate this point.

3.2.1. Example 1: shallow wells in Zambia

Shallow wells were first mentioned in the stakeholder mapping discussion as an alternative water source and hotspot for water borne diseases. They were later observed in the community by researchers during the transect walk and researchers found that residents were not open to talk about shallow wells, with their location and use being regarded as a secret subject due to them being prohibited and sometimes filled in.

> *"Burying of the shallow wells is a challenge as they complain that they do not have water…the buried shallow wells are usually unburied proving to be a challenge to control"*. (Z1, KII)

In both the young and older mixed-gender discussion, participants mentioned that some residents pay 50 cents (USD) a month to the shallow well owner to access water while other shallow wells were free of charge. It was later revealed during the KII interviews that these wells were banned in the community during the 2018 cholera outbreak in Lusaka. Further, it was also revealed during the water score card observations that the water from these wells were used for other households' activities and not for cooking and drinking and provided a strategy to cushion the cost of water and manage intermittent water supply.

> *"People say water does not kill and that is why they use water from the shallow wells despite being told that it is contaminated"*. (Z1, Young FGD)

3.2.2. Example 2: portable toilets in South Africa

During a mapping stakeholder interview, we learned about an informal settlement in S3 that is regarded as a temporary relocation settlement. People here are awaiting to be moved to receive serviced plots (including water and sanitation facilities) through title deeds. In their temporary location, they received shared water kiosks, standpipes, and portable toilets. When we visited the settlement during a transect walk, we observed a few rows of portable toilets along a road located opposite the site. Asking residents on the street, we learned that about 4-6 households must share these facilities. Community leaders, during a stakeholder/key informant discussion, explained that the portable toilets are looked after to avoid misuse of the facilities. When they are blocked, the residents send an SMS to report the problem. This leads to the porter potties being replaced if they are beyond repair. The leaders confirmed that the toilets are used by temporary residents and cleaned daily by locals who are hired by the government and the waste is collected by trucks daily:

> *"The temporary toilets are cleaned daily. These toilets are used by the people who are waiting for the serviced plots to be installed."* (S3, Stakeholder discussion)

During the water/sanitation scorecard observation, we saw two government-employed women cleaning the toilets using chemicals and brooms to clean the surface area. The toilets were tilted to let the excess cleaning water flow out from the porta toilet. No locks were present outside the toilets, but the toilets can be locked from inside.

3.3. Additional methods in the BBS—water and sanitation scorecard

The water scorecard was integrated into the BBS sequence to enhance data collection and interaction with infrastructure, complementing other methods. The scorecard revealed information on both visible and invisible formal and alternative infrastructures, allowing researchers to interact with these infrastructures, while also receiving input from residents. Below we provide an analysis of varied interactions with similar and different water and sanitation infrastructure in the four study communities, from the scorecard. See Figures 2–5 to support this analysis.

Figure 2 shows all the water sources observed in the four study areas. When using the water scorecard, the data collection team suggested that some of these sources were of much higher quality than others. For example, in Z1 private taps were assessed to be relatively higher quality, the water kiosk and standpipe kiosk had

TABLE 8 Water and sanitation options in the four communities and from which method(s) the data were obtained.

Community	Water options		Sanitation options	
	Water	Data source(s)	Sanitation	Data source(s)
Z1	***Formal water options***		Ordinary pit-latrines	Mapping FGD, Transect walk, Weekend observation, FGDs, Water scorecard, KII
	Communal water (kiosk)	Transect walk; mapping FGD; Weekend observations	VIP latrines	Transect walk, Water scorecard
	Boreholes	Mapping FGD; Transect walk; Water score; FGD	Pour flush	Water scorecard
	Private taps	Mapping FGD; KII; Water score	Flush (Indoor and Outdoor)	Water scorecard
	Alternative water options		Piped sewer	FGD, KII
	Stormwater drainage	Mapping FGD, Transect Walk, Weekend observations, FGD, Water score card, KII	Bucket latrines	FGDs, KII
	Shallow wells	Mapping FGD, Transect walk, Weekend observation, FGD, Water score card, KII	"Flying toilets" (opaque beer cartons, plastic bags, and bottles)	Mapping FGD, FGDs, KII
	Scoop well	Transect walk, Water score card		
	Filling station	FGD, IDI-GPS		
	Old council pipe	IDI-GPS		
	Stream	Mapping FGD, Transect walk, Weekend observation, FGD, Water score card, KII		
	Rainwater	Additional observations		
Z2	***Formal water options***		Lusaka Sanitation Program Toilets (LSP)	Transect walk, FGD, Water scorecard, KII
	Potable water from LWSC	Mapping FGD, Transect walk, Weekend observation, FGD, Water scorecard, KII	Pour Flush	FGD, Transect walk, Water scorecard
	Boreholes	Mapping FGD, Transect walk, Weekend observation, FGD, Water score card, KII	Dry and Ventilated pit-latrines	Mapping FGD, Transect walk, FGDs, Water scorecard
	Alternative water options		Communal Toilet (Fee paying)	Mapping FGD, Transect walk, FGDs, Water scorecard, KII
	Households and Churches with private boreholes	Mapping FGD, Transect walk, Weekend observation, FGD, Water scorecard, KII	Flush toilets	Transect walk, FGDs
	Leakages from pipes	FGD, KII		
S3	**Formal water options**		Communal Flush Toilets	Mapping FGD, Transect walk, FGDs, Water scorecard, KII
	Communal water (kiosk) (metered)	Mapping FGD, Transect walk, FGD, Water scorecard, KII	Indoor Flush toilets	Transect walk, FGDs, Mapping FGD
	Communal water standpipes	Mapping FGD, Transect walk, FGD, Water score card, KII	Concrete Flush Toilets (yard)	Transect walk/drive, Mapping FGD, FGD, Water scorecard, KII
	Private concrete taps	Mapping FGD, Transect walk, FGD, Water scorecard, KII	Portable Chemical Toilets (communal)	Transect walk/drive, Mapping FGD, FGD, Water scorecard, KII
	Private shared taps (metered)	Mapping FGD, Transect walk, FGD, Water scorecard, KII	Bucket Toilets	Mapping FGD, FGD, KII
	Private indoor taps (metered)	Mapping FGD, Transect walk, FGD, Water scorecard, KII	Open Defecation	Mapping FGD, FGD, KII
	Alternative water options			
	Illegal pipe connections	Transect walk/drive, Water scorecard, KII		

(Continued)

TABLE 8 (Continued)

Community	Water options		Sanitation options	
	Water	Data source(s)	Sanitation	Data source(s)
S4	**Formal water options**		Indoor flush toilets	Mapping FGD, Transect walk/drive, FGDs, Water scorecard
	Private indoor taps	Transect walk/drive; Mapping FGD; Gender FGD	Concrete flush toilets (yard)	Mapping FGD, Transect walk/drive, FGDs, Water scorecard
	Private Concrete Taps (metered)	Transect walk/drive; Mapping FGD; Water scorecard	Bucket toilets	Mapping FGD, FGD
	Alternative water options			
	Private boreholes	Transect walk/drive		

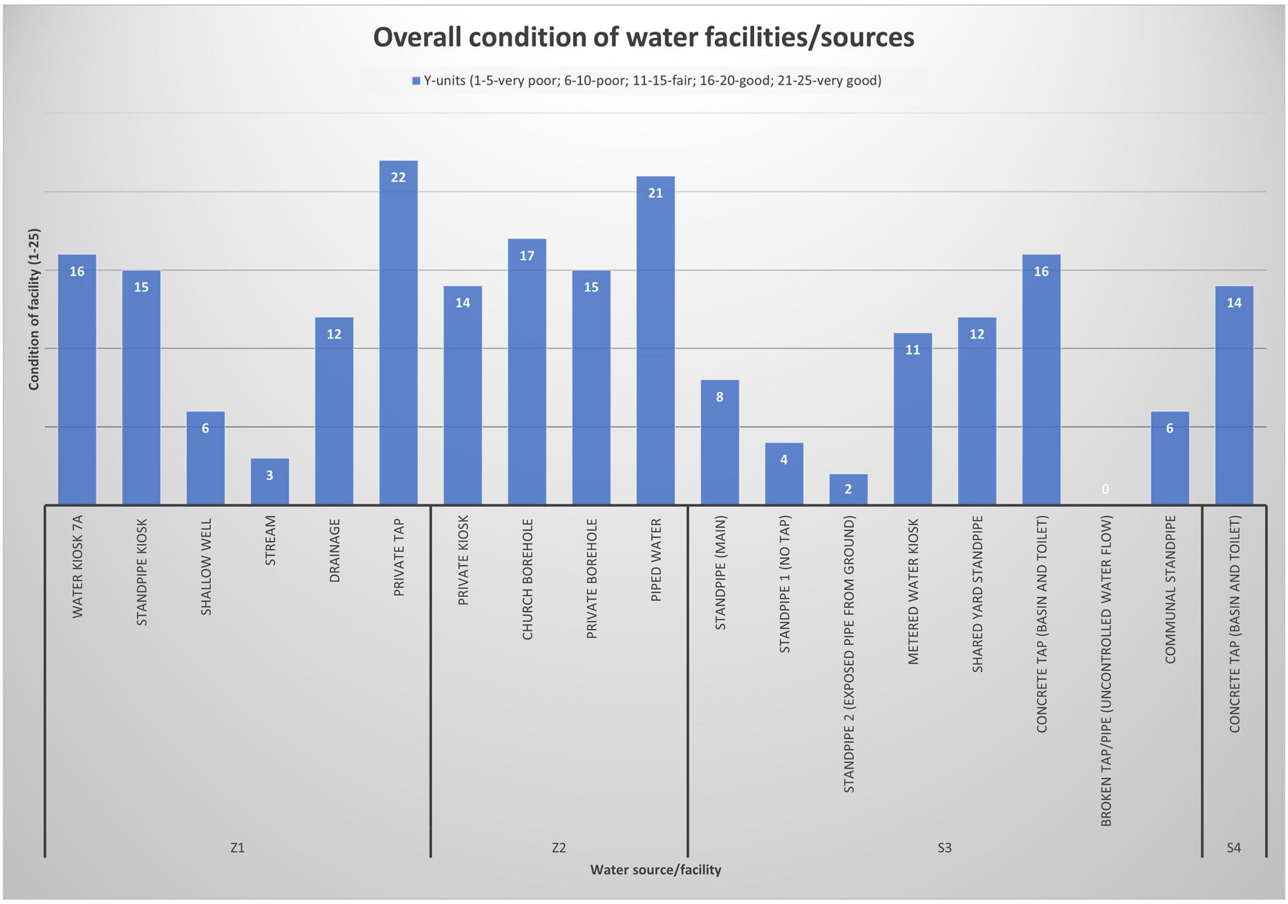

FIGURE 2
Overall condition of water facilities/sources.

relatively moderate quality, whereas the shallow well, local stream, and a drainage culvert were assessed as relatively low quality. Overall, residents with private taps or taps from serviced plots were assessed to have better quality infrastructures than those who collected water from broken communal taps or natural sources like streams and wells. In Figure 4, we illustrate 3 photographs of communal water standpipes/kiosks from piped water in Z1 and S3. The photographs highlight why the same type of infrastructure could be scored variably in different contexts. For example, the standpipe in Z1 scored higher because the surrounding area was visibly cleaner with a more functional structure than the standpipes in S3. Additionally, using the scorecard activity allowed testing for leaks and gathering resident experiences regarding accessibility and networks related to a tap or water collection from neighbors. For instance, shallow wells in Z1 were used for other household activities and not for cooking and drinking and provided a strategy to cushion the cost of water and manage intermittent water supply.

In Figure 3, the range of toilet options observed and assessed using the water and sanitation scorecard, suggested that the Lusaka Sanitation Program Ventilated Improved Pit latrine (LSP

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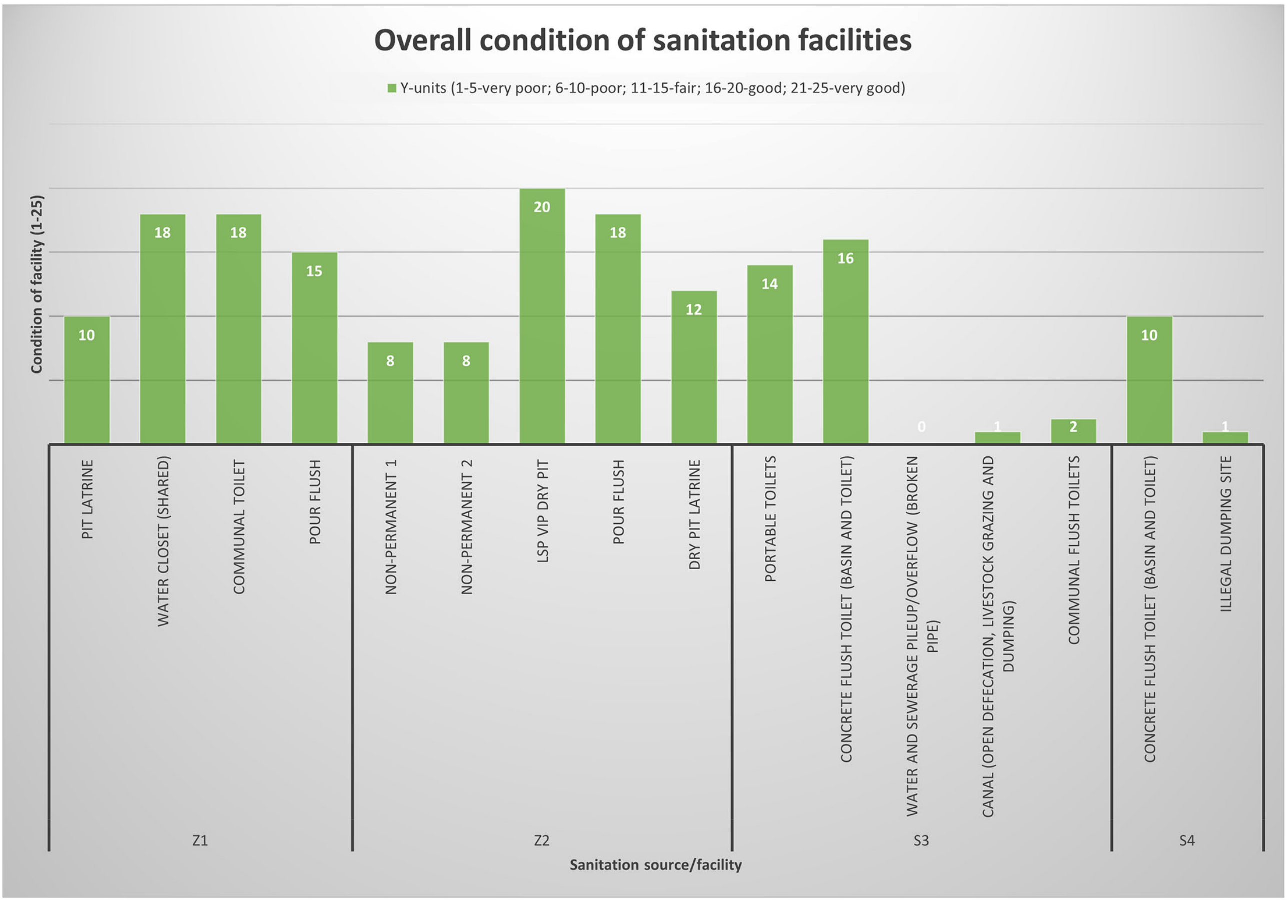

FIGURE 3
Overall condition of sanitation facilities.

FIGURE 4
Conditions of piped water.

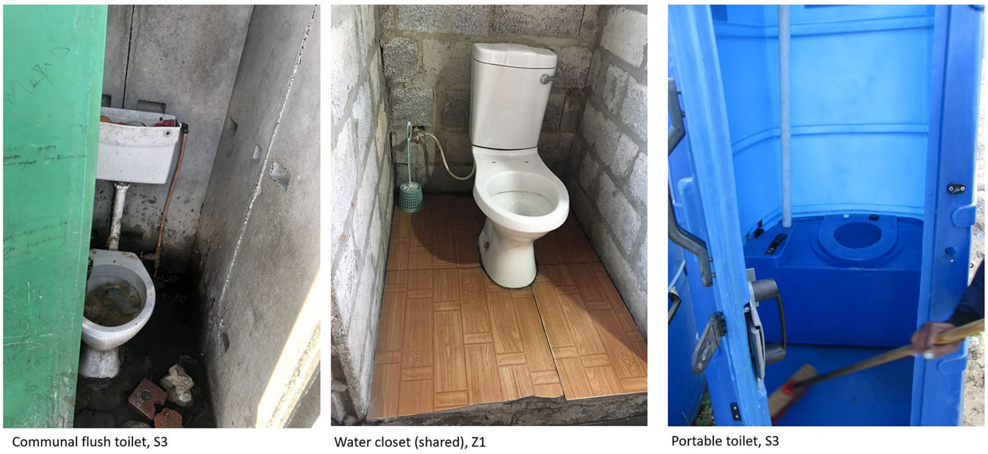

FIGURE 5
Conditions of toilets.

VIP dry pit) were of the highest quality, followed by pour flush in Z2, and shared water closet and communal toilet in Z1. Communal flush toilets in S3 were assessed to be of lowest quality due to poor maintenance of the toilets. The photographs in Figure 5 illustrate how portable toilets in S3 were better maintained than the communal flush toilets that were overflowing, and blocked with waste and building rubble. Hence, the photos in Figure 5 provide clarity on why communal flush toilets scored lower. These examples underscore the importance of considering both physical aspects of sanitation infrastructure and residents' experiences and preferences. While flush toilets are often assumed to be the best option, they can be financially challenging to maintain for both residents and local authorities, unlike temporary options like portable toilets or non-flush toilets (dry pits). Shared toilets can lead to breakages, putting financial strain on households to fix them or facing prolonged wait times for authorities to intervene, as observed in a shared yard flush toilet in S4.

Furthermore, indiscriminate waste dumping poses an additional challenge to communal water and sanitation infrastructures, particularly affecting stormwater drains, open spaces, and natural areas. In Figure 4, we observed a communal standpipe in S3 located near a heavily polluted river canal, filled with waste and sewage. Despite the tap's functionality and good water pressure, the obvious unsanitary conditions pose health risks, as confirmed by residents in the area who complain about open defecation practices and the spread of water-borne diseases. The close proximity of waste accumulation and water infrastructure results in unsanitary conditions, as evident in Figure 3, where an illegal dumping site (S4), a canal near communal taps (S3), and sewerage overflow from a broken pipe (S3) scored very poorly in the assessment. This highlights the critical need to address waste management issues to safeguard the health and well-being of communities relying on communal water and sanitation facilities.

3.4. Stakeholder dissemination

Community dialogue meetings were used in all communities to engage with residents, CBEs and local authorities to discuss preliminary findings using participatory approaches. In Zambia, community members agreed that the findings were a true representation of their community's situation. Residents said that although they knew what was happening in their community, the findings including pictures helped them understand the severity of their sanitation situation for example, indiscriminate dumping of solid waste in the stream. Community members also attributed the use of "flying toilets" and using water from shallow wells and the drainage, to financial constraints to construct toilet structures, lack of space, and reducing monetary expenses. The discussion also brought to light that the TWT faced challenges meeting community demands as they only have one reservoir tank.

In South Africa, dialogue meetings revealed new information. This included: how illegal waste dumping has become more pervasive; how higher prices of water have led to more people collecting "free" water from farmlands; how the construction of a major road could have contributed to more drainage issues in the RDP area next to a wetland; and how some political ward councilors/leaders claimed that political rivals sabotaged by dumping waste to weaken the ruling government. Community members mentioned service delivery improvements, such as the government's attempt to enlarge the sewerage pipes to prevent blockages and residents being allocated serviced plots with private water and sanitation facilities. They expressed the need for the government to actively assist them and to implement WASH interventions in their communities.

After community dissemination, findings were shared with national WASH stakeholders, focusing on the need to find sustainable solutions such as administrative spills over areas for unplanned settlements. The stakeholders also discussed how WASH problems were hard to address due to the unplanned nature of the communities and spoke of the need to find funding for interventions and carry vulnerability assessments accompanied with decentralized innovations.

4. Discussion

We, an interdisciplinary team of social scientists and engineers, conducted a rapid qualitative assessment approach termed a Broad Brush Survey (BBS) over 12–15 days in four sub-Saharan African urban communities in 2021 to depict the local context of water and sanitation infrastructure, services and needs. We conducted this BBS fieldwork during an evolving COVID-19 epidemic and other short (for example national mourning in Zambia), and longer-term challenges (for example, threat of violence in South Africa). The BBS approach involved background research, community entry through political authorities, qualitative data collection in a set sequence of observations, focus group discussions and key informant interviews, and iterative analysis structured by a meta-indicator framework. In a geographically bound community, the meta-indicator framework encompasses: physical features, social organization, social networks and community narratives. Using these meta-indicators systematically illustrated the interface between local context (physical and social) and water and sanitation infrastructure, moving from broader to narrower qualitative observations to build up a layered profile of each community. With systematic data at hand, we could then analyze commonalities and differences across the in-country communities, and across the two countries, for the purpose of water and sanitation infrastructure. The community profiles were rapidly written up using the meta-indicator structure and communicated to the communities and other relevant stakeholders, who were able to use the data for local reflection and/or action linked to water and sanitation. In the discussion, we firstly reflect on the strengths and limitations of the BBS approach applied to water and sanitation infrastructure from an interdisciplinary perspective, and secondly on how findings on water and sanitation contribute to the wider literature in this field.

The BBS approach is not novel for providing a rapid qualitative assessment since the principle of rapid assessment and the use of different combinations of qualitative and participatory methods to this end are well established, and in use for both research and intervention (Vindrola-Padros and Johnson, 2020). With the focus on a geographically bounded community and rooted in sociology and anthropology, the BBS approach is more akin to a rapid ethnographic assessment (Sangaramoorthy and Kroeger, 2020). Within this rapid qualitative assessment field, the BBS makes a clear contribution by using a meta-indicator framework, developed from urban systems theory (Wallman et al., 2011), and a set sequence of qualitative data collection activities and iterative analysis. This combination provides an organizing logic to combining various qualitative data into an overall description of the community, allowing for an understanding of the local context applied to a key research/and or intervention issue, and systematic comparison across communities involved in a study. Ahead of applying the BBS approach to water and sanitation, it has been proven useful to research, community engagement and intervention in six population-based large research studies on Tuberculosis and HIV in SSA (Bond et al., 2019), and continues to be used by interdisciplinary teams in public health population-based research. A BBS manual has recently been developed that should extend the core application of the BBS approach (Bond et al., 2023). Therefore, the application of the BBS approach to water and sanitation infrastructure and with engineers is another test of the usefulness of the approach for applied research and intervention.

This was the first time for engineers to be involved in adjusting and implementing the BBS approach and the first time to our knowledge to apply BBS to water and sanitation infrastructure. The novelty of working with engineering issues was limited to a new topic of application rather than a foundational change in conceptual underpinnings or processes. The water and sanitation literature increasingly acknowledges the importance of transcending disciplinary boundaries, and the potential usefulness of integrating social science with engineering to improve understanding and management of water and sanitation demands by bringing attention and detail to multiple factors that influence equitable water and sanitation access (Lund, 2015; Workman et al., 2021; Tsekleves et al., 2022). Engineers in the research team found that the BBS approach offers valuable insights into both physical and non-physical aspects that are challenging to quantify from a purely technical perspective. Transdisciplinary research faces a pitfall due to differing data collection norms between social sciences and engineering, with engineering emphasizing repeatability, controls, and quantitative results. The meta-indicator and set sequence approach of BBS allows for repeatability and consistency, aligning well with engineering experimental design norms and facilitating cross-comparisons across communities. Additionally, the rapidity of the BBS approach provides detailed insights within the shorter timescale typically required for engineering studies.

Engineers in the team had a particular influence on the addition of a water score card to the BBS data collection activities. The water score card drew on a water and sanitation checklist from the World Health Organization's (WHO) water/sanitary inspection package (WHO, 1997; Roque et al., 2022) (see Supplementary material 1). Research topic specific data collection tools can be integrated into the overall BBS sequence (Bond et al., 2019), and the water and sanitation scorecard is another example of doing this. Although the scorecard has limitations due to subjectivity, it proves valuable in offering an overview of the range of water and sanitation infrastructure within and across communities and the infrastructure accessibility and functionality for those who use these facilities. Utilizing additional tools in BBS enables further analysis to inform the meta-indicators. For instance, in the case of the scorecard, the physical structure, social interactions, user experiences, access and control patterns, and related narratives are observed and documented, and can be utilized in water engineering decision-making.

The involvement of community agency and stakeholders in improving water and sanitation service provision is an established approach, with critical reflections on the use and adjustments of participatory approaches for water services and development (Roque et al., 2022). The water engineers in the research team proved particularly important in organizing interaction with WASH stakeholders throughout the study. BBS is another pragmatic, flexible approach to add to this toolbox. In each of the communities included in this research we made local-level recommendations for priorities to be addressed in water and sanitation. We presented the community-specific findings in dialogue meetings and shared posters and flyers of the community profile findings with communities and stakeholders. These were displayed locally within certain amenities, and led to some local action including increased awareness of water and sanitation challenges and stakeholder commitment to improve or extend water and sanitation infrastructure.

It should be noted however that this is not a proof demonstrating how findings from the BBS approach have been used to change water and sanitation services. Nor did we directly compare a BBS approach to other rapid approaches to understanding water and sanitation in communities. Extrapolation from our findings should therefore be made cautiously and limited to settings and applications that are similar. Our assessment of the potential feasibility and utility is based on the interdisciplinary project team's opinions. We have substantiated our opinions with examples, but there is an inherent risk of bias since many of us are the developers of the approach.

Other limitations of the BBS approach are that standard qualitative approaches are sacrificed to the interests of a rapid, snap-shot approach. For example, the principles of sampling to saturation and iterative recruitment, data collection, and analysis, are compacted into a limited number of fieldwork days. This means the BBS approach is a more limited, less nuanced understanding that other more in-depth and extensive qualitative approaches. However, we suggest that we have shown that despite this acknowledged limitation, there is still significant utility to the combination of meta-indicator framing with the patchwork of stepwise data collection activities we have outlined. Another limitation is the risk of portraying a designated political and administrative geographical area as a community when it is in reality many communities, as exemplified by S3 and S4.

From the findings we yielded, we could draw comparisons with published literature, which further confirms the usefulness of the BBS approach. The inadequacy of formal water supply systems, toilets and solid waste disposal linked to urban expansion, unplanned settlements and broken infrastructure evident across all four communities in this study resounds with the documented strain on and challenges with formal water and sanitation services observed by other literature (Govender et al., 2011; Amin and Cirolia, 2018; Cinnamon and Noth, 2023). Despite government initiatives in both countries to improve water and sanitation access in urban areas, their implementation has been evaluated as fragmented, lacking community involvement (World Bank, 2016; NDP, 2022). The social organization of water and sanitation infrastructure in the four communities was fragmented and varying, spread across government, NGOs, CBEs, commercial enterprises and faith-based organizations. There were also notable examples of community action in both countries, particularly in response to solid waste management. Further, formal initiatives provided some employment for local residents trained to maintain, safe-guard and often charge for water and sanitation services. Frustrations and feeling neglected in the face of inadequate and demeaning water and sanitations services was palpable and voiced across all four communities, and echoed by other literature (Kennedy-Walker et al., 2015; Ato Armah et al., 2018; Enqvist and Ziervogel, 2019; Rambaree et al., 2019).

Infrastructure development is also juggling need with limited natural resources. Water shortage is a crisis in both cities (Chitonge, 2011; Simukonda et al., 2018; Robins, 2019). Our research, along with other studies (Madonsela et al., 2019), shows that inequitable access to water disproportionately affects lower-income and certain racial groups. For instance, in the Cape Town communities, backyard households with meters may run out of water for flushing or need to inform neighbors when doing laundry. In Lusaka, as noted in other literature (Simukonda et al., 2018; Reaver et al., 2021) residents resort to informal water sources (shallow wells) and rationed water points due to affordability issues.

Formal service planning often overlooks the interaction between place and services, neglecting the importance of informal practices for service delivery (Maryati et al., 2018). Our BBS findings highlight the significance of informal water sources and arrangements for accessing water, toilets and disposing of solid waste. This included the sharing of water and sanitation services, based on economic exchange and/or social networks. For example, households sharing or lacking toilets in the two Lusaka communities is a pattern evident in our own research and other studies (Simukonda, 2015; Tidwell et al., 2018). These informal practices provide options in the absence of formal, accessible, functioning and affordable infrastructure, and also contribute to the informal economy, providing income while compromising safety and health (Maryati et al., 2018; Yang et al., 2018; Nabirye et al., 2023). Our findings highlight the exploitation present in some informal practices, such as varying charges for accessing water. Research in Indonesia suggests that transforming informal systems into formal ones could potentially improve water quality (Maryati et al., 2018). Stakeholders in both cities are aware of informal practices but lack formal recognition and engagement with them. Engendering more infrastructure ownership may help recognize and include informal practices in future planning.

5. Conclusion

In SDG6, water and sanitation is described as ensuring access to water and sanitation for all but implementation is often far behind these ideals (Burton et al., 2021; Sutherland et al., 2021). We believe, whilst acknowledging limitations, that we have demonstrated the potential usefulness of the BBS approach as a rapid, flexible yet rigorous methodology for assessment of context-specific water and sanitation infrastructure challenges in SSA cities, building on a growing body of evidence (Bond et al., 2013, 2019). The appeal of BBS lies in providing a packaged list of activities that make qualitative methods more accessible to non-social science specialists, including engineers, and a framework (the four meta-indicators) that provides the platform for systematic data collection in communities and comparison across communities. Additionally, use of the BBS approach with other disciplines contributed to an applied understanding of the social and environmental factors to consider in planning and implementing water and sanitation programmes. Furthermore, the informal and formal range of water and sanitation infrastructure and community perspectives about both options emerged through the BBS data. This has revealed the influential role of informal systems in shaping urban landscapes, thereby prompting a re-evaluation of the prevailing perception that formally planned urban areas represent the ultimate goal (Priya et al., 2019). Priorities for future research to further evaluate and develop the BBS approach are (a) wider implementation by users who are first-time adopters of the approach, (b) application across multiple and diverse settings, and (c) evaluating the feasibility of training local community members to lead and implement the approach.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Stellenbosch University Ethics Committee in South Africa (reference Number N20/10/115), University of Zambia Biomedical Research Ethics Committee (Reference Number 1393-2020) in Zambia, the London School of Hygiene and Tropical Medicine (LSHTM) Ethics Committee (Reference number 25789), and the University of Sheffield (Reference number 042825) in the United Kingdom. The studies were conducted in accordance with the local legislation and institutional requirements. Written voluntary informed consent was obtained from all study participants above the age of 18 years. Young people below the age of 18 years gave voluntary informed assent before participating in the study. Additionally, written informed consent was sought from parents or guardians of young people below 18 years old who participated in the study. Additionally, photographs of individuals that were recognizable in the photograph were only taken and stored if written informed consent was obtained. Permission was sought for taking photographs of infrastructure that would identify a place and an explanation was provided that photographs would only be used to provide visual aid to illustrate research findings. Likewise, verbal consent was sought when conducting community observations at places of significance to WASH in the communities.

Author contributions

VB, GH, JS, EM, VS, LV, HJ, and MSimw contributed to conception and design of the study. MN, ZM, JM, TC, VB, MSimu, and EM collected data. MN led on the first draft of the manuscript. MSimu, JM, TC, and VB wrote sections of the manuscript. All authors contributed to the manuscript revision, read, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsc.2023.1185747/full#supplementary-material

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