GLOBALIZATIONS
https://doi.org/10.1080/14747731.2024.2434302

Routledge
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On a journey to citywide inclusive sanitation (CWIS)? A political economy analysis of container-based sanitation (CBS) in the fragmented (in)formal city

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ABSTRACT

Rapidly growing cities face the chronic challenge of access to safe, dignified and accessible sanitation, in contexts of inequality and informality. Technological and operational innovations, such as container-based sanitation (CBS), are promoted as relatively low-cost market-based circular economy off-grid solutions to deliver citywide inclusive sanitation (CWIS). However, in the absence of evidence that CBS is delivering on these promises, this paper asks: under what conditions can CBS services contribute to achieving CWIS goals? It applies a combined political economy and socio-technical regime analysis to examine multi-level governance in the sanitation sector and CBS service regimes in Cape Town, Lima, Nairobi and Cap-Haitien. Only Cape Town, a municipality-controlled system, demonstrates the necessary public authority that enables CBS to operate at scale. Yet, it is regarded by many residents in informal settlements as poor sanitation for poor people. This suggests that scaling CBS requires sustained public investment and strong coordinating authority.

ARTICLE HISTORY
Received 4 April 2024
Accepted 21 November 2024

KEYWORDS
Political economy; container-based sanitation (CBS); informal settlements; Governance; urbanization; citywide inclusive sanitation (CWIS)

1. Introduction

The proportion of the world's population living in cities is projected to rise to 80% by 2050, with 90% of this rise concentrated in Asia and Africa (World Economic Forum, 2022). Most cities are struggling to incorporate the urban poor into formal planning, infrastructure and governance systems, consequently reinforcing historical social, economic and political divisions (Oldfield, 2015; Wacquant, 2008). The provision of improved sanitation within these cities intersects with the dynamics of extreme inequality where the poor and rich live side-by-side (McFarlane, 2023; McFarlane et al., 2014). Significant levels of informality, with complex political, social, technical, and infrastructural

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This article was originally published with errors, which have now been corrected in the online version. Please see Correction (http://doi.org/10.1080/14747731.2024.2447174).

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dynamics characterize systems of basic provisioning in rapidly expanding cities (Criqui, 2020). This paper is interested in the capability and control of formal agencies in service provision and regulation, and in how these interact with 'informality' in service provision and access.

Whilst city scale 'on-grid' provision of sanitation is often the stated aim of government planning, in reality construction rarely keeps pace with the rapid expansion of the city. In this process, different configurations of collective 'off-grid' public and private action attempt to solve immediate needs for sanitation services, resulting in highly differentiated coverage and access to sanitation across the city (Dovey et al., 2021; Heidler, 2024). This produces complex arrays of non-state and private actors seeking profits (private and social) from waste collection, processing and management (Schindler, 2017); as well as self-supply and the private coping strategies of residents (van Welie et al., 2018).

Container-based sanitation (CBS) systems contain human excreta in sealable, removable cartridges used within a standalone toilet. Previous research has examined the potential for CBS to extend sanitation access, and to provide safely managed, lower cost processing of faecal waste as part of citywide inclusive sanitation (CWIS) approaches (Dewhurst et al., 2019; Russel et al., 2019; Van Riper et al., 2022). The promotion of CBS as a service regime is part of a larger narrative on the evolution of the off-grid city and is therefore attractive to actors seeking to promote off-grid market-based sanitation systems, which address an assumed impossibility of extending large city-scale sewered sanitation infrastructure (Russel et al., 2019). However, recent research suggests that no current safely managed urban sanitation system could be described as *low cost* (Igarashi et al., 2023). Citywide inclusive sanitation (CWIS) approaches, in common with many similar World Bank promoted technocratic approaches downplay the politics of urban spaces and assumes that a formal plan, which names CWIS as an aim, equates to the necessary public authority, capability and resourcing commitment to achieve implementation (Caprotti et al., 2022; Heidler et al., 2023). This paper, therefore, raises the question: under what conditions of public authority can CBS services contribute to achieving goals of citywide and inclusive sanitation?

The off-grid city does not neatly encompass a binary of on-grid/off-grid in commensuration with formality/informality. Situating CBS as part of a socio-technical sanitation regime for informal settlements tends to reinforce an overly simplistic formal-informal binary in understanding the city and masks the broader political economy dynamics that produce particular patterns of service regimes (Criqui, 2020; Geels & Schot, 2007; Heidler, 2024; Mitlin & Walnycki, 2020). It is the case that wealthier populations living in formal housing frequently purchase 'off-grid' services, and these may be formal or informal, e.g. a high-rise apartment with a septic tank occasionally emptied by an unlicensed operator. It is, therefore, vital to take a complex view of off-grid service delivery with the whole city (Caprotti et al., 2022).

This paper draws on interdisciplinary empirical research on CBS systems operating in Cape Town (South Africa), Nairobi (Kenya), Lima (Peru) and Cap Haitien (Haiti) from 2020–2023 to contextualize CBS systems in relation to the formal aim of citywide inclusive sanitation. Our approach draws on the literature from critical urban studies, urban political ecology, the political economy of service delivery and socio-technical regimes to develop a framework for situating CBS as a service regime within broader city sanitation sectoral regimes in order to provide a more realistic assessment of its potential. The juxtaposition of CBS service regimes in four different sanitation sectoral regimes suggests that CBS can contribute to addressing the acute need for safely managed sanitation, but can only do so at scale when there is sufficient public authority over operational control and resourcing. In particular, the heavily aid-sponsored NGO/social enterprise models show significant limitations in scale and sustainability in the absence of

political commitment and public investment. Regardless, the question of whether CBS is poor sanitation for poor people; a temporary stopgap measure; or a transformative sanitation solution for the city lingers.

2. Public authority and sanitation services in the 'grey spaces' of the city

Urban informality is often associated with the poor of the urban South (Davis, 2006; Hart, 1973), who live outside the state's regulation (Roy, 2009). Though they comprise a substantial proportion of the urban population, they have limited or no rights to the city (Lefebvre, 1996; Purcell, 2016). Being and surviving in the city presents dynamic and multi-layered bundles of rights, exclusions, relationships, differentiations and possibilities (Holston, 2009). There is often no fixed boundary between the formal and informal – rather, many practices exist in the grey spaces between strict formality and informality (Yiftachel, 2009). There is also growing evidence of the extent and significance of elite and middle-class informalities. These forms of informality are significant because they are both a reaction to subaltern informality (i.e. wealthier segments of the population struggle to defend and advance their vision of the city against poor migrants) and a result of the weak capability of the state to enact its' bureaucratic, governance and service delivery functions to the satisfaction of residents (Kelsall, 2012).

Systematic exploration of the political economy of urban informality reveals that the interactions of different actors simultaneously offer opportunities for extraction, exploitation, and exclusion for diverse groups across different domains of the city (McFarlane, 2012; McFarlane, 2023). Particularly across conditions of informality in the urban South, many actors exercise public authority, and these actors produce, and are produced by, multiple forms of urban governance (Anciano & Piper, 2018). In situations where the state is unable or unwilling to realize the right to water and sanitation for citizens, and where demand for these rights is acute and growing, city authorities can allow or enable different forms of authority to arise (Anciano & Piper, 2018; Truelove, 2019). Formal city authorities may also legitimize the work of non-state actors exercising public authority shaping patterns of 'informal' activity, land use and service provision (Schindler, 2017). For example, in Bangalore (India) and Nairobi (Kenya), where the government do not provide municipal water connections to non-authorized informal settlements, informal markets governed by private sector/water mafias fill the spaces, supplying these areas at premium rates (Banks et al., 2020; Ranganathan, 2016). City authorities often lack the capability and political willingness to regulate these provisions. Ultimately, the boundary between legality and illegality becomes a 'grey space' (Truelove, 2019; Yiftachel, 2009).

Where fragmented public authority results, this can increase inequality and decrease or disperse public accountability, making it difficult to direct a collective voice to demand service improvement or redress for failure. These grey spaces exist and expand in part with the tacit or explicit permission of the state, often compounded by its weakness or willingness to engage. Wealthy and middle-class voices dominate in governance processes and resource allocations within the city (Melber, 2016), becoming rooted in infrastructural inequalities with implications for the trajectories of the future. The planning and implementation of formal infrastructural development may thus actively or passively degrade the living conditions of some people relative to others, manifested in what some label as 'infrastructural violence' (Kumar et al., 2021; Rodgers & O'Neill, 2012).

A significant problem is the way that development agencies and formal governance institutions tend operate, as if there is no grey space can be ignored, or easily formalized through

planning and policy processes (Ofori et al., 2021). A political economy approach necessitates attention to the multiple bargains of different actors and interests. Our work in this space relates to other recent emerging work e.g. Heidler (2024). This is central to this paper's aim, as the distribution of public authority across formal and informal spaces directly impacts the application and operation of new forms of service delivery. It is, therefore, necessary to examine the broader political economy of sanitation sectoral regimes across the city to contextualize new service regimes such as CBS within it. Figure 1 below attempts to capture the multi-level complexity of understanding sanitation services both from a formal dimension (the system in theory) and the actually existing grey space where the informal and the formal are intertwined (the system in practice) (Rizzo, 2017). The central column of this figure relates to the level of public authority incorporating the nation-state, the city, sectoral regimes (i.e. sanitation) and service regimes (forms of sanitation, e.g. sewered network, CBS, septic tanks). A political economy lens contextualizes socio-technical sanitation regimes in relation to the wider historical and political evolution of the city as whole.

This is necessary to emphasize the specificity of public authority in particular locations. In theory, the relationships between levels of public authority are formalized through the managerial architecture of plans, policies, strategies, programmes and projects. This is represented by the left-hand column of the figure and expressed in the formal documentation and actions of the responsible agencies at each level. Evidence suggests that the gap between the system in theory and how the system operates in practice is often wide and deep (Mdee et al., 2022; Mdee & Mushi, 2020). This is particularly so when policy, planning and strategy exist as 'fantasy plans' with the function of giving the appearance of capacity and control to formal agencies and structures (Clarke, 1999; Mdee et al., 2024; Weinstein et al., 2019). Yet, cutting across all institutional levels, on the right column, is the too often ignored politics of power and service delivery. Without cognizance of this, mainstream development intervention acts as an 'anti-politics' machine, oversimplifying, favouring technical 'solutions' and burying the political contestation of fundamental

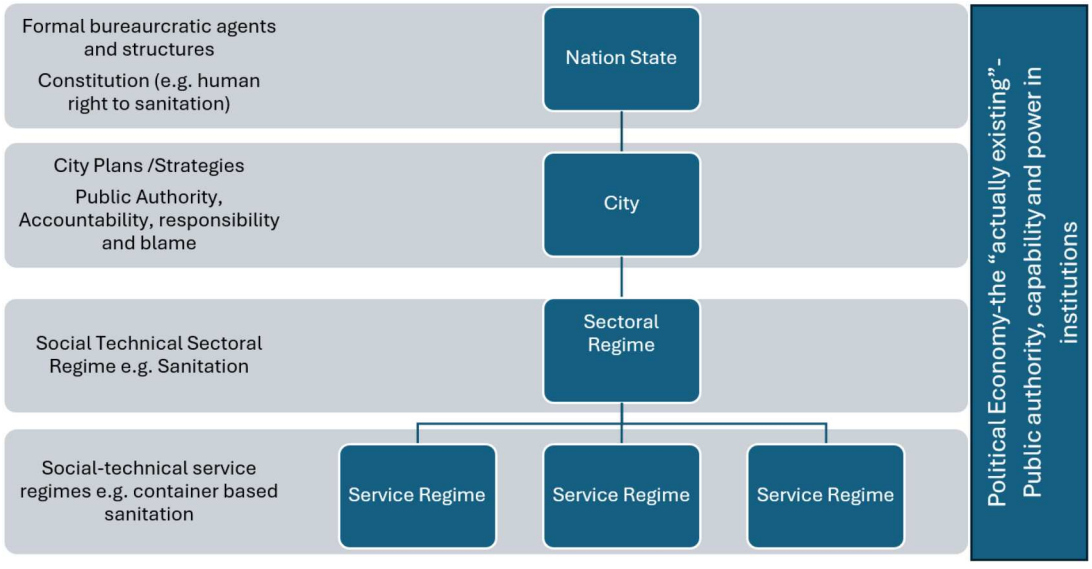


Figure 1. Sectoral and Service regimes Framework (authors' own).

questions about how societies should be ordered (Green & Hulme, 2005; McFarlane & Silver, 2017; Venugopal, 2022). Sanchez (2019) applies the notion of the anti-politics machine in order to examine how sanitation programs in Myanmar fail as they hide political-economic dimensions behind technical apolitical intervention.

2.1. Working with the political economy of sectoral and service regimes

The combination of a political economy approach with a socio-technical regime analysis enables a complex and nuanced analysis of how and why particular sanitation regimes evolve. Adopting the concept of socio-technical regimes allows differentiation between elements (service regimes such as CBS) that collectively form a sectoral focus, e.g. sanitation. A socio-technical regime refers to 'the institutionalized set of rules in an organizational field, the everyday practices of the actors (e.g. producers, workers, consumers, state agencies, societal groups, and business people who participate in the regime), artefacts, and markets that govern the nature of basic services (Geels & Schot, 2007; Lawhon & Murphy, 2012; van Welie et al., 2018). Applying a political economy approach to a socio-technical regime requires analysis of state capability (Andrews et al., 2017), power in and between institutions (Heidler, 2024; Kashwan et al., 2019) and accounting for the historical and continuing legacies of infrastructural violence that underpin sanitation inequalities in rapidly growing cities (Kumar et al., 2021). This makes change processes uncertain, heterogeneous and politically contested (Criqui, 2020; van Welie et al., 2018). As Criqui (2020, p. 176) explains; 'in cities of the Global South, sociotechnical change is messy, and the demand appears to be rather conservative; doubt is thus cast on the possibility of a paradigm shift that would improve access to water and sanitation for all. Like urban planning, policies and practices in the context of informal urbanization, actually existing practices in service delivery are pragmatic, erratic bricolage'.

To answer the question of whether service regime innovations such as CBS can enable a transition to citywide inclusive sanitation requires both consideration of higher-level political economy (as described in the previous section) and the particular localized political economies of sectoral and service regimes. To unpack this, we draw on van Welie et al's (2018) work on sanitation pathways and Batley and McLoughlin's (2015) work on the politics of service delivery.

Batley and McLoughlin (2015) argue that, at a sectoral level, the delivery of basic services must be differentiated by *service characteristics* and these are conditioned by the nature of the goods and services; market failure characteristics; task-related characteristics; and demand characteristics. van Welie et al. (2018) differentiate further in making specific analysis of the aggregate sector and

Table 1. Components of a sanitation service and sectoral regime (Author's own drawing from van Welie et al., 2018).

Service Regime	**Infrastructure and organizational mode** – the physical components of the service and mode and capacity of managing it, within specific spatial and temporal contexts, and differentiated across the sanitation value chain.
	Rationale and social interaction – the interactions of users, service providers and other actors in engaging with the service.
	Political economy incentives (service elements) – features of market failure, task and demand characteristics and local power dynamics
Sectoral Regime	**Political economy incentives (aggregate)** – features of the market failure, task and demand characteristics and sectoral power dynamics
	Alignment and interoperability – how service elements relate to and work efficiently and effectively with each other.
	Public Authority, regulation and capability – power and capability of institutional structures and processes
	Configuration type (monolithic, polycentric, fragmented, splintered) – an assessment of the nature of alignment of service elements and the distribution of power and authority (see Figure 2)

specific service regimes that constitute it. Table 1 sets out the analytical elements of these combined approaches that we apply to our empirical case studies.

It is essential to consider how particular service regimes operate in relation to others and how these service regimes aggregate at the sectoral level. van Welie et al. (2018) argue that a regime's strength is produced through alignment and weakness through misalignment. Aligned service regimes ensure smooth interoperability between different service regimes, producing coherence and complementarity between different service providers, supported by enabling regulations and policies. Contrarily, misaligned regimes are characterized by inefficiency in service provisioning within different service regimes and a lack of appreciation and recognition for the divergent service regimes operating within the sector. Based on this, van Welie et al. (2018) provides four configurations of sectoral regimes (monolithic, polycentric, fragmented and splintered regimes), characterized by the number of service regimes, their interoperability and interaction with other service regimes. We introduce a fifth configuration, an ad-hoc regime where household coping strategies and self-supply dominate sanitation patterns (Figure 2).

In a monolithic system, there is one dominant service regime, tightly regulated and controlled, e.g. a publicly owned service monopoly. In a polycentric system, several service regimes comprise the sectoral regime, but they are, in theory, well aligned with high interoperability, accountability and regulation. This is the ideal type under the neoliberal governance mode (World Bank, 2004). More commonly observed outcomes of neo-liberal governance are the fragmented and splintered modes. In a fragmented sectoral regime, separate service regimes may be well aligned, but the relationships between them are misaligned. In a splintered sectoral regime, the service regimes are internally misaligned. We have built on van Welie et al. (2018) and added ad-hoc (disconnected) service regimes to represent a conflict/post-conflict situation where pockets of aligned or misaligned service regimes exist, but the majority of activity is centered on the coping strategies of individuals and households.

3. Methods

This paper emerges from a multidisciplinary research project conducted in Cape Town, South Africa, Lima, Peru, Nairobi, Kenya and Cap Haitien, Haiti and is based on data from the political economy and intersectional vulnerabilities workstreams. The project is a collaboration between participating universities, CBS enterprises in three cities (Sanima, Lima; Sanergy, Nairobi; SOIL, Cap-Haitien) and local country partners with extensive experience working in their local contexts. The empirical data underpinning our analysis comes from extensive key informants interviewing,

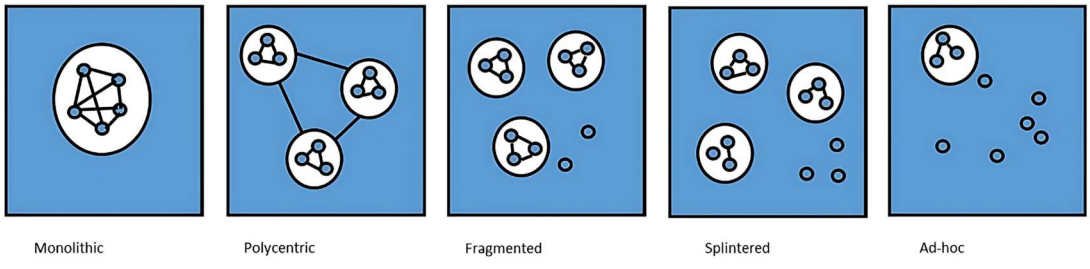


Figure 2. Five types of sectoral regimes – sectoral regime (large square) encompassing service regimes (big circles), and dimensions of service regimes (smaller circles), and alignments represented by lines between them.

policy analysis and observation with relevant stakeholders across all levels of the sanitation regime, extending from donors and staff in national ministries to local leaders and sanitation users residing in particular informal settlements. Each country team received local ethical clearance. The project took an active partnership approach to working with CBS providers. Key informant interviews took place at all levels of CBS operations and with users. A joint project-level approach was agreed in consortium meetings but was adapted as necessary for each case study.

Political economy analysis aims to provide a reasoned explanation for how a particular situation/assemblage of factors exists in time and space (Mdee et al., 2021). It seeks to understand institutional configurations, their relationships to each other and the outcomes that this produces. This type of analysis reveals actual complexity and nuance as power can be inferred by identifying who dominates narratives, decision-making and control of resources (Anciano & Piper, 2018; Kashwan et al., 2019; Mdee et al., 2017). In this case, we apply a political economy lens to the empirical analysis of four CBS services and the sanitation sectors in the four different cities. In each city, we analyze the nature and operation of a CBS service regime and its alignment with the broader sanitation sectoral regime. Analysis of the findings has been a collaborative and iterative process using the sectoral and service regime framework above. We followed a process of inductive and deductive thematic analysis, validated and triangulated findings with stakeholders through private meetings and in public fora. Some individual country results include Ferguson et al. (2022); Mallory et al. (2022) and Dube et al. (2023).

Through a multi-level analysis of how CBS service regimes align with sectoral regimes in four different contexts, we provide a juxtaposition of these four cities. This is specifically not intended for identifying 'best practice' but rather for understanding the structural nature of particular local outcomes (Cooper-Knock & Ndlovu, 2021). This allows for an informed analysis of the potential contribution of CBS towards the vision of citywide inclusive sanitation.

4. Assessing the current and potential contribution of CBS to the vision of citywide inclusive sanitation

This section provides a brief narrative account of sanitation sectors and CBS service regimes in each of the cities, drawing on literature review and empirical findings. We then summarize our analysis of sectoral and service regimes using the framework outlined in Table 1. This is presented in Tables 2 and 3. In Table 3 we classify these four cities as demonstrating four of the five regime types described above: Cape Town (monolithic), Lima (fragmented), Nairobi (splintered) and Cap Haitien (Ad-hoc).

4.1. Cape Town

The legacy of apartheid remains pivotal to the political economy of sanitation in South Africa and the role of public authority in service delivery (Dube et al., 2023; Feinberg & Horn, 2009). Although significant sanitation coverage (81.3%) has been achieved through improved sanitation infrastructure, approximately 7.67 million individuals (31%) lack adequate (locally defined) sanitation facilities in urban areas (Statistics South Africa, 2019).

The state's obligation to provide and deliver sanitation is enshrined in the post-apartheid 1996 Constitution, which guarantees South Africans the right to sufficient water and a healthy environment. When the state fails to fulfil these basic rights, court summons against the state have played a role in demanding public provision of dignified sanitation (Dugard, 2016). South Africa's

Table 2. Comparison of sectoral sanitation regimes in four cities.

Sectoral Regime	Cape Town – South Africa 96% safely managed[1] 8% non-sewered	Nairobi – Kenya 34% safely managed 50% non-sewered	Lima – Peru 46% safely managed 8% non-sewered	Cap Hatien – Haiti 1% safely managed 100% non-sewered
Configuration Type (from fig 2)	Monolithic (Dube et al., 2023)	Splintered (See Mallory et al., 2022; van Welie et al., 2018)	Fragmented (Criqui, 2020)	Ad-hoc
Political economy incentives (city level)	Municipality service obligations funded through local/national government Post-apartheid liberation state with significant inequality.	Informal settlements assumed to be on an undefined pathway to formalization. High degree of informality in sanitation in 'formal' housing areas. Post-colonial elite settlement founded in colonial city governance. Significant influence of aid/ international donor agendas.	Unequal and colonial history of the city with informal settlements on the steep desert terrain. Since 1990,s a neoliberal approach to service delivery but has increased coverage gradually. People must organize collectively as 'community organisations' and build infrastructure e.g. retaining walls, to prepare for sewer investment.	Political and governance fragility. Massive expansion of low-income, informal urban settlements over recent decades, consistently riven by competing political factions and gangs within informal settlements.
Alignment and interoperability of CBS in wider sanitation sector	High – monolithic	Low – splintered	Medium – fragmented	Ad-hoc
Public Authority and regulatory capability	High – monolithic but responsive to protest and citizen demand. High monolithic regulatory capability limited by public resourcing constraints.	Low-medium – splintered authority with high levels of blurring between formal and informal power. Low – splintered formal institutional capability. Informal settlements also exist with alternative public authority in the form of cartels.	Medium – fragmented public authority. Medium – capability is constrained by political patronage, bureaucratic barriers and weak political interest in informal settlements.	Ad-hoc – very limited public authority. Ad-hoc – Chronic lack of formal regulation capability. DINEPA has 1 core staff member (2023) and is entirely dependent on donor funds.

Note: [1]These figures are drawn from 'shit flow diagrams' https://sfd.susana.org/about/the-sfd-promotion-initiative. These are modelled estimates of faecal waste management in specific cities. Here they are illustrative of broader sanitation sectoral characteristics.

sanitation sectoral regime can be characterized as monolithic, with the state assuming the responsibility of providing and delivering basic access to sanitation through devolving delivery to local municipalities, who can further contract with private service providers.

The City of Cape Town (CoCT) provides free basic sanitation services to residents in over 200 informal settlements. The target ratio for sanitation is one shared toilet for a maximum of five households (City of Cape Town, n.d.). Sanitation services within informal settlements consist of full flush toilets in communal blocks (approximately 20% of the toilets in informal settlements), while the rest are catered to through forms of CBS such as chemical toilets, container toilets, and portable flush toilets (PFTs) and shared standalone sewered toilets. Private providers are awarded contracts through tenders to supply, deliver, and service these toilets, with an estimated annual value of R120 million (~6.3 million USD). However, these numbers barely meet the ever-increasing demand for sanitation in informal settlements (Jackson & Robins, 2018). In practice, the City of Cape Town is financially constrained and can only provide an additional 1,000 PFT units per quarter. The majority of PFT users belong to historically marginalized groups who previously relied on the bucket system during the apartheid era. Consequently, these technologies are labelled 'second-class solutions for second-class citizens' (Redfield & Robins, 2016, p. 145). This

Table 3. Comparison of CBS services regimes across four cities.

CBS Service Regime	Cape Town – Khayletisha Portable Flush Toilets (PFTs)	Nairobi – Mukuru (Sanergy)	Lima – Pamplona Alta (Sanima)	Cap Haitien (SOIL)
Infrastructure and organizational mode	**Household toilets –** Fiamma camping toilets, serviced by private contractors with waste to municipality wastewater treatment facility **Scale:** 40,000 + units free to households	**Freshlife toilets** shared in compounds, toilet units leased and subsidized payment for emptying. Emptying done by workers and processed into animal feed or fertilizers. Sanergy also provides a facility for manual pit emptiers. **Scale and Pricing:** 6000 units in Nairobi with monthly service of $6 per month. Cost of production per unit is $450	Household dry toilets, urine and faeces separated. Workers collect waste weekly at collection points and disposed of at a municipality-authorized facility **Scale:** 1400 units with monthly service at $10 per month. Cost of production per unit =$130	EkoLakay dry household toilets. Workers collect waste on a weekly basis and processes waste to produce compost **Scale:** 2700 customers Cost is $1.10 to $2.30 per month to customer. Costs SOIL $40 to provide full service per customer
Rationale and Users perception	One of several temporary solutions provided by the City of Cape Town under service and human rights obligations to informal settlement residents. **Users and civil society:** PFT is the least bad option: better than some other options but still viewed by many users as a bucket toilet (Dube et al., 2023)	Promoted as a circular economy solution for informal settlements in Kenya. Nairobi City County has shown a passing interest, similar to other aid-funded projects, and some shifts in regulatory frameworks have been made to accommodate it. **Users:** It is better than nothing or existing facilities, but there are contesting views: e.g. 'this is one of the companies that has come to exploit Kenyans'.	Sanima currently operate on their own, with little government interest. There are no specific incentives or official positions in relation to alternative off-grid sanitation solutions. Assumed long-term sanitation service will be sewers. **Users**: A more hygienic solution than pit latrines with a good service, although temporary (until sewers come) and relatively expensive.	Haitian government promotes condominiums and community-managed septic tanks. Hence, Pit latrines, financed by households or aid, predominate in informal settlements. **Users** suggest that Ekolakay is better than open defecation. Even though some prefer a more permanent onsite solution such as pit latrines and septic tanks, they cannot afford them because of the upfront cost involved.
Political economy incentives (service elements)	Sanitation remains a site of intense local and national political contestation. PFTs are thus part of active local government problem-solving, in response to constitutional obligations and intensive service protest demands City of Cape Town argues cost of servicing is high, limiting service extension.	Sanergy is a self-styled 'social enterprise' but recent estimates suggest a cost recovery of 19% (See Mallory et al., 2022). It is runs an international staff with a large local staff. Actively negotiating MOUs with national government, and Nairobi City County. This is to secure government funding and regulatory support for non-sewered sanitation	Sanima is partially financed by user fees, but dependent on aid/donor resourcing. It serves a clientele who can afford the monthly servicing fee Sanima has evolved reflectively as an organization in promoting CBS as the ultimate solution (see Medem, 2021)	SOIL partly financed by user fees (10-15%) but remains dependent on aid/donor resourcing. Serves a clientele who can afford installation and service fees. SOIL has evolved as an organization, starting with a social enterprise/cost recovery model abut now exploring public service subsidy models for vulnerable individuals.

delivery gap has allowed donor-backed NGOs to experiment with alternative technologies (Redfield, 2022). However, these alternate measures are consistently met with social resistance, not only as an expression of a preference for conventional sewered solutions but as a pressure on the state to deliver 'first-class technologies' to poorer communities.

4.2. Nairobi

Nairobi's colonial history built the foundations of extreme sanitation inequalities in the city, producing a fragmented sanitation sectoral regime with responsibilities scattered across multiple state departments, with informal settlements rendered 'illegal' and out of state responsibility (Crozier, 2005; Greenwood & Topiwala, 2020; Nyanchaga & Ombongi, 2007). Kenya is an enthusiastically neo-liberal state with a significant role given to the role of private actors in the governance and delivery of public goods and services. Enabled by heavy donor financing in basic services within the post-colonial political settlement, the Kenyan state's role was to provide incentives for market efficiency, while privatization was expected to address service deficiencies and achieve economic viability (Kithiia & Majambo, 2020; Nyanchaga & Ombongi, 2007). Official planning systems prioritize formalization of basic service delivery and sewered sanitation provision, but this has not kept particularly in pace with population growth in formal or informal settlements. Nairobi City County apparently feels little pressure to serve marginalized populations, despite sanitation being recognized as a human right in the constitution (Mallory et al., 2022). van Welie et al. (2018) label Nairobi as a 'splintered sectional regime' composed of six service regimes in Nairobi alone (e.g. domestic sewer regime, shared on-site regime, public sanitation regime, communal facilities and the container-based regime). These service regimes show high levels of misalignment and lack of interoperability (Fischer et al., 2021).

The most visible NGO provider of CBS in Nairobi, Sanergy, offers an end-to-end service involving the removal and transportation of faecal waste from residents to central processing plants, through the leasing and servicing of household and compound toilets. Sanergy aimed to reach one million urban residents by 2022 with their Fresh Life toilets but has not achieved this number. In March 2022, an employee of Sanergy estimated the number of currently leased Fresh Life toilets to be approx. 4000 and the latest estimate that we have is approaching 6000 units (Jan 2024). e-Pact evaluation reports indicate that Sanergy's operation cost is approximately $20 per person per year (pppy), whereas revenues stand at $12pppy (White et al., 2019). The containment and emptying aspect of their work is considered 'non-profit,' relying on grants and donations, posing a significant threat to long-term sustainability. Sanergy aims to align its non-profit aspect with the Nairobi City Water and Sewerage Company through a public-private partnership management contract model. This estimated cost is pegged at $10pppy (currently subsidized through donations and external funding) but contingent on Sanergy being the sole sanitation provider in all of Nairobi's slums (Waldman-Brown & Flatter, 2018). However, the Government of Kenya's spending on sanitation and hygiene is currently $3pppy (White et al., 2019).

4.3. Lima

Peru's sanitation sectoral regime is produced from a colonial history of extreme inequality with informal settlements predominated by indigenous Peruvians with poor services (Hudson, 1993; Ioris, 2012; Saco, 1995). Thus, in Lima, despite individuals in affluent neighbourhoods having full access to sewered sanitation, only about 43% of the population in the lowest wealth quintile are connected to a sewer network (Mujica & Uriarte, 2016). Past pro-market liberalization agendas sought to restructure sanitation governance, delivery, and provision with the goal of achieving technical and managerial efficiency (Ioris, 2012). This led to the establishment of the National Office for Services of Sanitation (*Superintendencia Nacional de Servicios de Saneamiento* – SUNASS) – the regulator and Lima Sewerage and Water Supply Service – SEDAPAL (*Servicio de Alcantarillado*

y Agua Potable de Lima) – the public provider (Torero & Pascó-Font, 2003). SEDAPAL was initially intended as a private utility provider, but this faced intense opposition (Ioris, 2012). It is argued that poorer areas in Lima have become the testing ground for various sanitation schemes, described as the new paradigm of sanitation since the late 1990s (Fuertes et al., 2008). This has created multiple service regimes in Lima and a fragmented sanitation sectoral regime comprising of; domestic sewers, shared on-site regime, public sanitation regime, community-based organizations, coping sanitation regimes, and the container-based/urine diversion regime (Calizaya et al., 2009; Roman et al., 2011; World Bank Group, 2019). Politically, SEDAPAL remains committed to pursuing the 'modern infrastructural ideal' (sewered systems), and aims to retain control over its network and client base. However, in practice, different service regimes face misalignments and capability challenges with heavy expectations on poorer communities for collective action and contribution of labour (Criqui, 2020; Durand, 2012; Furlong, 2014). NGOs that attempt to address the sanitation gap in cities often find themselves entangled in bureaucracy and politics which reinforce infrastructural inequalities (Medem, 2021; Oswald & Hoffmann, 2007).

Sanima (formerly X-Runner) remain the only CBS provider operating in Lima, Peru. It owns approximately 1,400 toilets and serves over 7,000 people (X-Runner, 2020). Users pay a fee for the provision of the toilet and the servicing of the unit (Mujica & Uriarte, 2016; World Bank Group, 2019). SANIMA operates below its operating costs (World Bank Group, 2019). In 2022, SANIMA received 74.2% of their revenue from grants, 24.7% from earned income, and 1.1% from donations (SANIMA, 2023). SUNASS currently lacks the mandate to regulate non-sewered sanitation. Thus, no revenue can be generated from the circular economy aspect of this sanitation service regime.

4.4. Haiti

Haiti is a state founded in the colonial revolution and characterized by chronic state failure and instability. The predatory nature of the Haiti political system and US-led political interference have contributed significantly to chronic instability and impoverishment (Fatton, 2011; Maguire & Freeman, 2017). Overall spending on public services has been remarkably low, resulting in an increasing population of urban poor in informal settlements with no access to proper and adequate sanitation (Neiburg & Nicaise, 2010).

Fatton (2011) argues that NGOs in Haiti have formed a parallel state by being the main providers of social and public services in Haiti, consequently undermining Haitian control of their own politics and economics. This has resulted in calcifying Haiti's position as a phantom state whereby governing institutions have extensive external resourcing but lack internal social and political legitimacy (Chandler, 2006). The sectoral regime of Haiti can be characterized as ad-hoc, with the capacity of the state and/or 'strengthening of Haitian institutions' existing on paper (Hersher, 2017). The Direction Nationale de l'Eau Potable et de l'Assainissement (National Directorate of Water and Sanitation (DINEPA)) created in 2009 was crippled by the 2010 earthquake despite the significant funding from external donors (Gelting et al., 2013). This research found that the sanitation division of DINEPA, which operates with only one full-time staff member, is severely capacity constrained and dependent on external funds.

Ramachandran et al. (2015) estimate that the Haitian government directly receive only up to 21% of humanitarian and donor aid. The remaining funds trickle through several channels including subcontracted NGOs and private contractors tasked to manage funds and deliver social services, with limited accountability and transparency. Sparkman and Sturzenegger (2016) have

argued that even with substantial investment, improving the nation's sanitation service regimes would not be a priority of the Haitian state. This was further confirmed in our interviews. For instance, the 2014–2018 Strategic Guidance Document for Sanitation, prepared by DINEPA, suggests families, rather than the state, will be 'encouraged' to build 500,000 new toilets and improve 700,000 existing toilets (DINEPA, 2014). Therefore, the sanitation service regime in Haiti is predominantly a domain for household coping strategies and self-supply serviced by configurations of private providers. The Haitian state has chronically limited capacity and public authority to regulate this provision.

The population of Cap Haitien is estimated to have doubled in population size in the last twenty years with 28% living in informal settlements (IDB, 2022). Biscan et al. (2020), in the SFD report for Cap Haitien, noted that only 1% of the faecal sludge is contained and safely treated and that this is primarily due to the efforts of Sustainable Organic Integrated Livelihoods (SOIL). SOIL, an NGO established in 2006, provides CBS through the EkoLakay toilet and servicing operations (Van Riper et al., 2022). SOIL operates below cost, only recovering 10–15% of costs through user fees and compost sales, and therefore heavily dependent on grants from a range of public and private donors. It also processes faecal waste into compost for sale and distribution. During interviews, SOIL recognized the limits of a market-based cost recovery model and is presently exploring subsidized access to services with financing from IDB. It is also embedded in relationships with local – and national-level institutions.

5. Assessing the current and potential contribution of CBS to the vision of city-wide inclusive sanitation

The juxtaposition of four different CBS service regimes within four sectoral sanitation regimes offers critical insights into understanding the potential role of CBS in a city's journey towards city-wide inclusive sanitation.

At the service regime level, it is evident that CBS offers a technology and operational system that could improve the users' toilet experience and in safely managing faecal waste beyond sewered (on-grid) systems or formalized off-grid systems. It is undoubtedly better than an unimproved pit latrine but not necessarily more than an improved bucket toilet. This is a view particularly strongly expressed in Cape Town and is underpinned by social and political dynamics and the active consciousness of citizens. However, this view is evident in all the cities in our study, but again, the strength of that expression also relates to citizen's expectations of service provision. In Lima, there is a greater expectation that the 'modern', i.e. sewered on-grid sanitation, will eventually arrive, partly driven by state's outlook on sanitation. In the meanwhile, CBS is an acceptable stop-gap measure if you can afford the fees. Nairobi's informal settlement residents express their anger about the lack of good services, but they have a more pressing priority for water and little expectation of the role of public authority in achieving inclusive sanitation for them. Instead, they rely on local cartels to provide alternative servicing arrangements. Customers of Sanergy appreciate the service but find the cost to be a burden and barrier to entry. In Haiti, the EkoLakay service is seen as better than open defecation but not necessarily better than an improved pit latrine or a flushing toilet with a septic tank. Toilet provision is predominantly onsite, and it is thought about as an individual family issue of affordability.

What is clear from the cases is that Sanergy, SOIL and Sanima are dedicated yet evolving organizations. As NGOs, each was essentially influenced by funding trends (and perhaps foundational beliefs) to position themselves as social enterprises pursuing market-based and circular economy

solutions to non-sewered sanitation. None of these organizations has been able to make that model work for full cost recovery, and all recognize that scaling up service provision requires investment and cross-subsidy through local authorities and national governments. Cape Town, in this regard, is very distinct. Though resource-constrained, the provision of CBS is free to informal settlement residents by the City of Cape Town and operates at a larger scale than in the other cases.

At the level of sectoral regime, each case study has contextually unique political economies, showing varying historical, institutional and political configurations. These reveal levels of public authority and capability and, therefore, offer insights into why CBS might be scaled in one place but not in another. Conceptualizing the potential for CBS to address sanitation inequalities and achieve CWIS requires contextualizing CBS in relation to the wider sanitation regime.

The City of Cape Town and South African post-apartheid history has been shaped by citizen protest and legal action in demanding the promised reparations of liberation. The history of informal settlements is deeply embedded in this history. Post-COVID and with worsening national economic conditions, Cape Town faces the pressure of increasing numbers of informal settlements springing up and is struggling with service delivery and expectations. Compared to the other cases, City of Cape Town has strong public authority and institutional capability, which enables a monolithic sanitation sectoral regime, with high coverage of formal sanitation, both sewered and off-grid. However, it is not necessarily perceived as such by residents of informal settlements, who see their continued precarious living conditions and comparatively substandard services to be symptomatic of failed promises. Hence, the CBS service regime addresses an immediate need and temporarily fulfils the obligation of the state. The question of whether sewered sanitation is achievable for informal settlements in Cape Town is further entangled with unresolved land ownership politics and strained and over-allocated water resources to wealthier parts of the city. Further, calls for non-sewered sanitation modalities justified by references to climate change, are framed by some as 'eco-apartheid' (Bigger & Millington, 2020).

Although the sanitation sectoral regime of Lima is currently fragmented, extending on-grid sewered sanitation is within the plan of SEDAPAL (i.e. they wish to move towards a monolithic regime), but the geographical location, topography and the politics of land ownership of Lima's informal settlements makes this challenging. Residents of informal settlements are expected to collectively organize and provide labor/resources towards basic infrastructure in a way that is not required of residents in wealthier areas. Water resources are also over-allocated, expensive and constrained, particularly in informal settlements. Whilst government public authority and institutional capability is fragmented by bureaucratic inefficiency, competing priorities, alleged corruption and variable political will to address inequality, it does appear to have signalled the intention to address sanitation in informal settlements, and hence incorporate and formalize, even though the timeline to achieve this ambition remains uncertain. CBS provided through market-based services then has become a 'temporary awaiting connection' option.

Meanwhile, in Nairobi informal settlements exist as states within states, such as the power and presence of 'cartels' who operate a hybrid modes of service delivery (Muindi et al., 2022). These cartels can be understood as patronage and rent-seeking networks enmeshed with the powerful interests that also run the formal state. In formal terms, the informal settlement is almost invisible, perceived as an illegal space housing the poor and uneducated. It becomes visible only if an externally funded aid intervention makes it potentially more lucrative for state and city actors to be involved or if residents need to be mobilized during election campaigns. Thus, public authority within the sectoral regime is therefore splintered, contested and competitive. The state can be powerfully authoritarian e.g. in using police in clearing informal settlements to install

trunk sewers or to clear land for roads; but also, overtly neglectful e.g. in incorporating the human right to water and sanitation in the constitution but failing to address access to safely managed sanitation. This is because of how formal and informal power is so closely connected. Informal settlement residents thus find their own solutions according to their capabilities. The city has very limited public authority, capability or interest to address safely managed sanitation challenges in formal areas of the city lacking on-grid sewered connections. To quote a retired Ministry official: 'People in their fancy new apartments with flush toilets are in reality, just shitting in the streets' (i.e. septic tanks are so inadequate that they are rapidly overflowing). In this case, then, CBS provision runs the danger of being another in a long line of NGO/externally funded interventions that may well come and go, e.g. the defunct sanitation NGO peepoople (Fischer et al., 2021; Mwangi & Maghanga, 2023).

Cap Haitien presents an extreme case of state incapability and lack of public authority. With the vast majority of sanitation being a private household responsibility across the country (ad-hoc), it is possible to see CBS as a market-based option for a wide proportion of the population. It is, however, limited by affordability and would certainly need external funding to extend to more vulnerable populations. However, it should be noted that DINEPA views CBS as a transitional technology, in meeting an immediate need and encouraging behaviour change in a rapidly evolving urban landscape.

6. Conclusion

The four cases suggest that we should guard against blanket generalizations and false hopes about the conditions of public authority under which CBS services could contribute to achieving city-wide and inclusive sanitation goals, and as an ultimate 'off-grid solution'.

Using political economy analysis combined with a socio-technical regime analysis of sanitation sectoral and service regimes, we have demonstrated how cities are inherently political spaces. Their patterns of inequality, service patterns and access reflect their histories and the struggles contained in that history. They reflect national political settlements regarding the position and rights of historically marginalized populations, which subsequently shape their future trajectories. In each of the four cities, we observe unique conditions and sectoral regime configurations where technological and operational modes, designs and practices contend with existing power structures, interests and institutional capability, signaling the significance of public authority as critical to enabling redistributive and interoperable sanitation sectoral regimes to evolve.

Our cases suggest that CBS can provide an improved and safely managed sanitation service regime, but the conditions for scaling such systems in informal settlements specifically only appear viable in fully monolithic and public sanitation sectoral regimes such as Cape Town, which have institutional structures to enact and manage public authority for specific outcomes. It is significant and important that the system in Cape Town is publicly funded and attempts to be explicitly redistributive to historically marginalized populations. In Cape Town, Haiti and Lima, CBS is framed in public authority terms as a temporary response to acute need on a journey to better services. The three CBS service regime providers in Haiti, Lima and Nairobi are social enterprises established on the basis that a market could provide public authority and institutional capability to extend access to safely managed sanitation services. In varying degrees, each of these CBS operators remains dependent on donor funds and has failed to scale up to any comparable degree to CBS in Cape Town. Thus, we conclude with two fundamental and practical considerations relevant to policy and practice.

Firstly, if CBS has a role as a 'temporary' solution to immediate needs, then it is far from clear how temporary this solution might be. A single technology/operational system cannot, just by itself, effect transformation without enabling structural conditions and public authority. The nature of the future pathways for any of these cities entails a more expansive analysis of not just sanitation but the wider question of all urban inequality dimensions (housing, land, employment, energy, water, education, health). Here, we agree with Fransen et al. (2024) that there is no guarantee of better futures without struggle. We might note that Nairobi is now experiencing anti-government protests led by some social movements interviewed in this research. Their struggle is against the elite political class, who hold public authority and deploy it for their benefit. Therefore, NGOs, such as Sanergy, are seen as problematic for upholding and supporting corrupt public authority (Mwangi & Maghanga, 2023).

Finally, CBS is argued to have dual potential to: (1) contribute to a paradigmatic shift away from sewered sanitation as the 'modern infrastructural ideal' and (2) act as a critical means to reduce water demand and promote nutrient recycling. It might, counterintuitively, be more politically necessary and better to focus on incentivising shifts in demand for CBS by richer and elite groups, whose market behaviour could then cross-subsidise systems and enable public authority that could be deployed with collective public benefit. This would signal that CBS is more than poor toilets for poor people.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The research work is supported by UK Research and Innovation's Global Challenges Research Fund (GCRF), grant number (ES/T007877/1).

Data availability statement

Data cannot be made publicly available. Readers should contact the corresponding author for details.

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Mdee, Anna L.; Ofori, Alesia D.; Barrington, Dani J.; Anciano, Fiona; Dube, Mmeli ...

2025-07
Taylor & Francis
https://doi.org/10.1080/14747731.2024.2434302
Mdee A, Ofori AD, Barrington D, et al., (2025) On a journey to citywide inclusive sanitation (CWIS)? A political economy analysis of container-based sanitation (CBS) in the fragmented (in)formal city. Globalizations, Volume 22, Issue 5, 2025, pp. 875-895

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