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Affordable Sanitation Systems and Their Role in Inclusive Public Health

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Abstract

Affordable sanitation systems are foundational to inclusive public health because they reduce exposure to fecal pathogens, protect dignity and safety, and narrow health inequities that disproportionately affect low-income households, women and girls, persons with disabilities, and informal-settlement residents. Despite progress, sanitation gaps remain vast: in 2022, 57% of the world (≈4.6 billion people) used safely managed sanitation, while about 3.5 billion still lacked it; 419 million people continued to practice open defecation. These deficits translate into preventable illness and lost productivity; diarrhoeal disease alone kills ~443,832 children under five annually, and a significant proportion is preventable through safe water, sanitation, and hygiene (WASH). This paper synthesizes evidence on "affordable sanitation" (low-capex and low-opex options appropriate to local context) and explains how well-designed, inclusive sanitation services—paired with behavior change, fecal sludge management, and governance—advance public health, equity, and progress toward SDG 6. We propose a practical framework for selecting affordable systems (technical feasibility, life-cycle cost, inclusion/safety, climate resilience, and service-chain performance) and outline policy and program actions to accelerate equitable sanitation outcomes.

Keywords: *affordable sanitation, inclusive public health, fecal sludge management, SDG 6, equity, WASH, low-cost toilets, safely managed sanitation*

1. Introduction

Sanitation is not only an infrastructure issue; it is a health-protection service that interrupts fecal–oral transmission pathways. Where sanitation is inadequate, pathogens spread through contaminated hands, food, soil, and water, increasing risks of diarrhoeal disease, enteric infections, helminthiasis, environmental enteropathy, and associated undernutrition—particularly among children. The health burden is intertwined with social exclusion: populations lacking safe toilets are more likely to be poor, live in rural or informal urban settings, face insecure tenure, or experience disability and gender-based constraints.

Global progress is real but insufficient. Between 2015 and 2022, the share of people using safely managed sanitation rose from 49% to 57%, yet the world remains off-track for universal access by 2030. WHO notes that in 2022 43% of the global population (≈3.5 billion) still lacked safely managed sanitation, spanning people using basic private toilets without safe management, shared sanitation, unimproved facilities, or open defecation.

Inclusion is central to public health impact. A sanitation solution that is technically "low-cost" but unsafe, inaccessible, or socially unacceptable may fail to be used, maintained, or sustained. Conversely, affordable

sanitation that is accessible, dignified, and safely managed across the entire service chain (containment → emptying/transport → treatment → safe reuse/disposal) can deliver large health gains and reduce inequities.

2. Conceptual framing: What counts as "affordable sanitation"?

"Affordable sanitation" is best defined by **life-cycle affordability** (capital + operation and maintenance + service fees) relative to household and municipal ability-to-pay, while meeting minimum safety and accessibility standards. Low upfront cost alone is not sufficient; systems that fail (e.g., due to flooding, poor pit design, lack of emptying services, or unsafe disposal) can impose higher long-run costs through disease, lost income, and environmental contamination.

2.1 Service level: from basic to safely managed

WHO's sanitation ladder distinguishes service levels—from open defecation to unimproved, limited (shared), basic, and safely managed sanitation—where "safely managed" requires improved facilities not shared with other households and safe disposal or treatment of excreta.

2.2 Inclusion as a design requirement

Inclusive sanitation means the system is usable by all—children, older adults, pregnant women, persons with disabilities, and people with chronic illness—while addressing safety (lighting, privacy), menstrual hygiene needs, and caregiving realities. This is not a "nice to have"; it directly affects uptake and consistent use, which determine public health impact.

3. Methods (narrative synthesis)

This paper uses a narrative review/synthesis approach, drawing on global monitoring and public health sources (WHO/UNICEF JMP, UN SDG reporting, WHO health burden resources) and economic evidence (World Bank sanitation economics initiative documents). Core statistics and definitions are taken from these authoritative sources and integrated with programmatic insights on affordable systems and inclusion.

4. Facts and figures: Why sanitation is a public health priority

4.1 Global coverage gaps

- Safely managed sanitation (2022): 57% (≈4.6 billion people).
- People lacking safely managed sanitation (2022): ≈3.5 billion.
- Open defecation (2022): ≈419 million.

Recent JMP reporting also emphasizes that, while billions gained access since 2000, progress is uneven and inequality persists.

4.2 Health burden and preventable disease

Diarrhoeal disease remains a leading killer of young children: ~443,832 deaths annually among under-5s, plus additional mortality in older children, and ~1.7 billion cases of childhood diarrhoea each year—much of which is preventable with safe water and adequate sanitation and hygiene. WHO also maintains SDG

indicator resources on mortality attributable to unsafe WASH, reflecting the continued health burden linked to inadequate services.

4.3 National snapshot example: India (SDG 6)

Country snapshots illustrate both progress and remaining gaps. For example, SDG 6 monitoring indicates that 63% of India's population uses safely managed sanitation (indicator 6.2.1a), while safely managed drinking water and hygiene indicators differ, underscoring the need for integrated WASH programming.

4.4 Economic implications of poor sanitation

Poor sanitation generates economic losses through healthcare costs, productivity losses, time costs, and impacts on tourism and education. World Bank sanitation economics work documents large, multi-sector impacts and provides a rationale for prioritizing sanitation investments.

5. Affordable sanitation system options and their public health logic

Affordable sanitation systems vary by density, hydrogeology, climate risks, and service capacity. The public health principle is consistent: contain feces safely and prevent environmental exposure, then ensure safe treatment and disposal/reuse.

Table 1. Common affordable sanitation options and inclusion/public health considerations

System type	Typical contexts	Public health strengths	Key risks if poorly implemented	Inclusion considerations
Improved pit latrine (with slab, ventilation where feasible)	Rural/peri-urban, low density	Low capex; can reduce open defecation	Groundwater contamination; flooding; unsafe emptying	Wider door, handrails, stable floor, adequate lighting/privacy
Twin-pit pour-flush	Rural/peri-urban; water available	Alternating pits allow safer decomposition; easier O&M	Water requirement; poor construction leads to leakage	Accessible pan height/handholds; path and superstructure design
Septic tank + soak pit/leach field (small-scale)	Small towns, peri-urban	Works where sewers absent; can be upgraded with desludging	Requires regular desludging; illegal dumping risks	Safe access for desludging; user-friendly toilet layout

Container-based sanitation (CBS)	Dense informal settlements	Service model can ensure safe off-site treatment	Requires reliable collection logistics and financing	Can be highly inclusive with thoughtful cabin design
Shared/community toilets (managed)	Dense settlements; transitional settings	Better than open defecation if well-managed	Poor management leads to low use and contamination	Safety for women/girls; disability access; cleaning accountability
Simplified/condominial sewers (where feasible)	Dense, planned/unplanned urban	Lower-cost networked solution; can improve wastewater control	Needs good design + governance; treatment capacity required	Household connection affordability; public accountability

Key point: "Affordable" should be assessed at **system + service-chain** level. A low-cost toilet without safe emptying, transport, and treatment can still leave communities exposed.

6. How affordable sanitation advances inclusive public health

6.1 Reduced pathogen exposure and outbreak risk

Improved sanitation decreases fecal contamination in households and neighborhoods. When combined with hygiene (handwashing with soap) and safe water, it can sharply reduce enteric disease incidence. WHO highlights that a substantial portion of diarrhoeal disease is preventable through WASH improvements.

6.2 Equity gains: reaching underserved groups

Inclusive public health requires closing gaps for those most exposed:

- **Low-income households** often face constraints on latrine construction, space, or service fees.
- **Women and girls** experience heightened safety risks and barriers linked to privacy and menstrual hygiene management.
- **Persons with disabilities** may be effectively excluded by steps, narrow doors, unstable floors, or lack of handrails.

Affordable sanitation programs that incorporate universal design features and targeted subsidies can increase consistent use, which is essential for health impact.

6.3 Time savings, school participation, and dignity

Sanitation access reduces time lost to seeking private places to defecate, waiting for shared facilities, or caring for sick family members. Improved school sanitation supports attendance and retention—especially for adolescent girls—by providing privacy and menstrual hygiene support. Economic analyses also highlight "time costs" and schooling/work impacts as meaningful components of sanitation-related losses.

6.4 Health system strengthening: WASH beyond households

Sanitation in health care facilities is critical for infection prevention and quality of care, especially in primary health care. JMP reporting on WASH in health care facilities emphasizes persistent gaps and the relevance to safe services.

7. Implementation essentials: what makes "affordable sanitation" actually work

7.1 Design for context and climate risk

Flood-prone areas need raised latrines or sealed containment; high water tables require careful siting and technologies that protect groundwater; dense settlements may require CBS or simplified sewers. Poorly matched technologies can fail quickly and undermine trust.

7.2 Ensure the full fecal sludge management chain

Where sewers are absent, fecal sludge management (FSM) is the backbone of safely managed sanitation. Programs must ensure:

- scheduled or on-call **safe emptying**,
- **transport** to authorized sites,
- **treatment** capacity,
- regulated **disposal/reuse**.

Without this chain, households may have toilets but communities still face exposure—one reason why "basic" does not automatically become "safely managed."

7.3 Financing and affordability mechanisms

Common approaches include:

- targeted subsidies for the poorest,
- output-based aid (payments linked to verified installations/service levels),
- microfinance for household toilets,
- municipal service fees with pro-poor tariff design,
- public–private partnerships for FSM services.

Economic evidence underscores that the costs of inaction can be substantial across sectors, supporting investment cases for sanitation.

7.4 Behavior change and sustained use

Even the best infrastructure fails if it is not used consistently. Community engagement, culturally appropriate design, and hygiene promotion are essential complements—particularly where shifting from open defecation to consistent toilet use is the core behavior change challenge.

8. Discussion: Linking sanitation to SDG 6 and inclusive development

Global reporting shows sanitation improvements but inadequate pace for 2030. Achieving inclusive public health benefits requires shifting from "toilet construction" to **service delivery**—with measurable outcomes (safe containment, regular emptying, treated waste) and equity metrics (coverage among poorest quintiles, disability access, gender safety).

A practical way forward is a five-criterion decision framework for affordable sanitation investments:

1. **Health protection:** expected reduction in exposure pathways
2. **Life-cycle affordability:** capex + opex + household/municipal affordability
3. **Inclusion and safety:** universal design + gender-sensitive features
4. **Service-chain viability:** FSM/treatment capacity and regulation
5. **Resilience:** performance under flooding, drought, and rapid urban growth

This framework encourages balanced choices rather than defaulting to "cheapest toilet."

9. Policy and program recommendations

1. **Define affordability using life-cycle costs**, not only construction cost; include O&M and FSM.
2. **Mandate inclusive design standards** for all publicly supported sanitation (ramps/handrails, wider doors, lighting, privacy locks, menstrual hygiene provisions).
3. **Invest in FSM infrastructure and enforcement** (treatment plants, licensing, safe disposal rules, monitoring).
4. **Use pro-poor financing**: targeted subsidies, vouchers, or output-based aid to ensure the poorest benefit first.
5. **Track equity and "safely managed" outcomes** using SDG-aligned indicators and local service data dashboards.
6. **Integrate sanitation with child health and nutrition programs**, focusing on high-burden districts/settlements.

7. **Support WASH in schools and health facilities** as essential public health infrastructure, not ancillary amenities.

10. Conclusion

Affordable sanitation systems are among the most cost-relevant and equity-enhancing public health interventions when they deliver safe, inclusive, and sustained services. Global monitoring shows major progress, yet billions still lack safely managed sanitation, and preventable diarrhoeal deaths remain unacceptably high. The path to inclusive public health is not simply building low-cost toilets, but ensuring context-appropriate technology, accessible and dignified design, behavior change, and a functioning fecal waste service chain. With life-cycle financing and equity-centered governance, affordable sanitation can accelerate progress toward SDG 6 and translate infrastructure into measurable reductions in disease and inequality.

References:

- World Health Organization (WHO). *Sanitation – Fact sheet* (updated 22 March 2024).
- WHO/UNICEF Joint Monitoring Programme (JMP). *Progress on Household Drinking Water, Sanitation and Hygiene* (2023 update; 2022 estimates).
- United Nations Statistics Division. *The Sustainable Development Goals Report 2024: Goal 6*.
- World Health Organization. *Diarrhoeal disease – Fact sheet* (7 March 2024).
- UN-Water. *SDG 6 Progress Reports* (overview and 2024 release information).
- SDG 6 Data Portal. *India – SDG 6 snapshot* (indicator estimates).
- World Bank / WSP. *Economic Impacts of Inadequate Sanitation in India* (Economics of Sanitation Initiative).