THE ROLE OF SANITATION IN HUMAN DEVELOPMENT: A HISTORICAL AND ENVIRONMENTAL PERSPECTIVE

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Abstract

Sanitation is an essential public-health service and an important component of sustainable human development. This review examines how sanitation systems have interacted with urban development and social well-being across historical and contemporary contexts. Rather than treating sanitation as a single cause of civilizational success or decline, the article considers plausible pathways linking safe excreta management, water protection, disease prevention, human productivity, and environmental quality. A narrative review approach is used to synthesize historical examples and contemporary policy evidence. The discussion highlights the development of drainage and water-management infrastructure in ancient settlements, the public-health reforms associated with industrial-era cities, and the continuing importance of safely managed sanitation in rapidly urbanizing communities. The evidence supports the conclusion that sanitation can contribute to healthier and more resilient communities when infrastructure is maintained, services are accessible, and waste is safely managed throughout the service chain. However, historical changes in population, disease, and economic performance are multifactorial; causal claims should therefore be made cautiously. The article concludes that sanitation policy should integrate public health, environmental protection, equity, and long-term operation and maintenance.

Keywords: *sanitation; public health; human development; urban environment; wastewater management.*

Introduction

Sanitation includes the systems, services, and behaviours required to manage human excreta safely, from the point of use to treatment and final disposal or reuse (Chandana & Rao, 2022). It is closely connected with drinking-water safety, hygiene, drainage, and the protection of receiving environments. When sanitation services fail, pathogens and nutrients can enter soil and water, creating exposure pathways for communities and contributing to environmental degradation (Lusk et al., 2017). Access to a toilet alone is therefore not sufficient to establish that sanitation is safely managed; containment, emptying, transport, treatment, and disposal also matter (WHO, 2024; WHO/UNICEF Joint Monitoring Programme, 2023).

The relationship between sanitation and human development is long-standing (Souza et al., 2025). Urban settlements require ways to manage wastewater and stormwater, protect water supplies, and limit contact with human waste. Archaeological evidence from settlements such as Mohenjo-Daro and the Roman world illustrates that water supply, drainage, and public infrastructure were important elements of

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urban organization (Angelakis et al., 2025). These examples demonstrate engineering capacity and collective investment, but they do not by themselves prove that sanitation caused a civilization to flourish or decline.

In industrial-era cities, crowding, contaminated water, and inadequate waste removal contributed to severe public-health challenges (Özer & Tansel, 2026). Reforms in water supply, sewerage, drainage, and public-health administration became part of broader changes in urban governance. John Snow's investigation of the 1854 cholera outbreak in London is an important episode in the development of epidemiological reasoning, while subsequent infrastructure investments formed part of a wider response to waterborne disease (Kappner, 2025). Such developments should be interpreted alongside other factors, including scientific advances, housing, nutrition, health services, and economic change.

Contemporary sanitation policy also has implications for equity and environmental sustainability. Inadequate facilities can disproportionately affect children, people with disabilities, low-income households, and menstruating students. Untreated wastewater can impair surface-water and groundwater quality, while poorly planned infrastructure can transfer pollution downstream or become vulnerable to flooding and climate-related hazards. Sustainable Development Goal 6 accordingly emphasizes access to water and sanitation and their sustainable management.

Despite broad recognition of these connections, historical narratives sometimes present sanitation as a direct explanation for complex outcomes such as the rise or collapse of civilizations, changes in life expectancy, or economic growth. Such statements require careful evidence and should distinguish association from causation. This article therefore synthesizes the historical and contemporary significance of sanitation, focusing on the pathways through which sanitation can support public health, social well-being, economic activity, and environmental protection. It also identifies limitations in using historical comparisons to infer causal effects.

Review Methodology

This article is presented as a narrative review rather than a systematic review. It synthesizes the historical examples and policy-oriented sources discussed in the original manuscript, together with established public-health framing on sanitation and safely managed services. The purpose is interpretive: to organize the evidence around four connected dimensions—public health, social inclusion, economic and institutional development, and environmental quality.

The original manuscript did not provide a reproducible database-search record, complete search strings, dates of searching, eligibility criteria, or a screening log. Those details cannot be reconstructed reliably from the submitted text and are therefore not represented here as completed systematic-review procedures. Before submission, the authors should either document an actual structured search and screening process or retain the narrative-review designation and explain how the cited sources were selected. Quantitative claims are included only where their source and context can be stated; unsupported numerical assertions have been removed.

Results and Discussion

Sanitation and the organization of early cities

Historical settlements developed different approaches to water collection, drainage, and waste management in response to local geography, materials, population density, and administrative capacity (Rojas et al., 2015). The urban systems associated with Mesopotamia and the Indus Valley, including Mohenjo-Daro, indicate that water management and drainage

were integrated into aspects of settlement planning. Roman aqueducts and drainage works similarly demonstrate substantial investment in urban infrastructure.

These systems should not be interpreted as equivalent to modern safely managed sanitation. Their performance, coverage, maintenance, and public-health outcomes varied, and the existence of infrastructure does not establish that all residents benefited equally. Nor is there sufficient evidence in the original source set to assign a specific population size, disease burden, or civilizational trajectory to sanitation alone. The more defensible inference is that collective water and waste infrastructure can support dense settlement when it is suited to local conditions and maintained over time.

Industrial-era public health and urban infrastructure

Rapid urbanization during the industrial era intensified the challenge of supplying clean water and removing human waste. In crowded settlements, disposal practices could contaminate drinking-water sources and increase opportunities for enteric disease transmission. The London cholera outbreak investigated by John Snow in 1854 is widely recognized as a landmark in epidemiology because it linked disease occurrence to a shared water source. The episode did not, by itself, solve urban sanitation; sustained improvements required infrastructure investment, public-health institutions, regulation, and ongoing maintenance.

The historical lesson is therefore institutional as well as technological. Sewer networks, drainage channels, and water-supply systems can reduce exposure only when they function as intended and are connected to safe treatment or discharge practices. Infrastructure can also create new environmental pressures if sewage is merely transferred to rivers without adequate treatment (Bernhardt et al., 2008). Evaluation should consequently consider the entire sanitation chain rather than the presence of pipes or toilets alone.

Contemporary links to health, equity, and economic activity

Safe sanitation reduces opportunities for human exposure to faecal pathogens and is an important component of preventing diarrhoeal and other sanitation-related diseases. The scale of benefit depends on service quality, community coverage, hygiene practices, drinking-water conditions, and local disease pathways. Sanitation also affects dignity, safety, privacy, and the ability to participate in education and work (Coswosk et al., 2019). Inadequate or inaccessible facilities can impose additional burdens on women and girls, people with disabilities, and marginalized households.

Healthier living conditions may support attendance at school and work and reduce avoidable demands on health services. Nevertheless, economic benefits are context-dependent and should not be represented by a universal return-on-investment figure without specifying the study, location, time period, and assumptions. Likewise, changes in stunting, school attendance, or productivity cannot automatically be attributed to sanitation alone because nutrition, healthcare, income, education, and other infrastructure also influence these outcomes.

For community-based environmental management, these findings imply that sanitation interventions should be designed with users and local institutions. Appropriate technologies must reflect settlement density, soil and groundwater conditions, water availability, affordability, and the capacity to operate and maintain the system. Community engagement is important, but it cannot substitute for safe treatment, regulation, technical oversight, and sustainable financing.

Sanitation and environmental sustainability

Sanitation is also a water-quality intervention (Piper et al., 2017). Inadequately contained or treated wastewater can introduce pathogens, organic matter, nutrients, and other contaminants into receiving waters. The resulting impacts depend on pollutant loads, receiving-water conditions, treatment performance, and cumulative discharges from households and other sources. Safely managed sanitation can help protect water resources, but the environmental outcome depends on the treatment process and the management of sludge and residuals.

Climate change and urban growth make resilience increasingly important. Flooding can damage facilities and spread faecal contamination, while water scarcity can constrain water-dependent sanitation systems. Decentralized treatment, resource recovery, nature-based approaches, and water-efficient technologies may be appropriate in some settings, but they require site-specific evaluation and evidence of operational performance. No technology should be described as sustainable solely because it is labelled "green" or "smart"; performance, life-cycle impacts, affordability, and maintenance requirements must be assessed.

Synthesis of the historical and contemporary evidence

Table 1 summarizes the principal interpretive lessons. It deliberately avoids ranking civilizations or presenting unsupported numerical comparisons, because the historical periods and indicators are not directly comparable.

Table 1. Summary of the Principal Interpretive Lessons

Context	Sanitation-related development	Interpretive lesson and limitation
Early urban settlements	Water collection, drainage, and local waste-management practices supported settlement organization.	Infrastructure indicates collective capacity; it does not prove that sanitation alone caused urban growth or social complexity.
Industrial-era cities	Water-supply, sewerage, drainage, epidemiology, and public-health administration developed in response to urban health risks.	Disease reduction depended on multiple interventions and institutional changes, not a single engineering project.
Contemporary communities	Safely managed sanitation can reduce exposure to faecal contamination and support dignity, inclusion, and environmental protection.	Benefits depend on coverage, service-chain safety, local conditions, maintenance, and complementary services.
Climate-resilient planning	Water-efficient, decentralized, and nature-based options may be useful where technically appropriate.	Claims of sustainability require site-specific performance, life-cycle, and operational evidence.

Overall, the evidence supports a qualified conclusion: sanitation is an enabling condition for public health and sustainable settlement, but it is neither a sufficient explanation for civilizational success nor an isolated determinant of economic performance. Outcomes are produced through interactions among infrastructure, governance, behaviour, environmental conditions, and access to other services.

Implications for Community-Based Environmental Management

For community-based environmental engineering, sanitation planning should begin with a diagnosis of local exposure pathways and

service gaps (Alves et al., 2025). Assessment should include toilet access, containment integrity, emptying and transport practices, treatment performance, final discharge or reuse, and potential effects on surface water and groundwater. Monitoring should use indicators appropriate to the intervention and should distinguish outputs (for example, facilities installed) from outcomes (for example, safely treated waste and reduced exposure).

Projects should also define responsibilities for operation and maintenance, identify realistic financing arrangements, and establish accessible feedback mechanisms for users. Where interventions are intended to improve water quality, baseline and follow-up measurements should be selected in advance and interpreted with attention to seasonality, upstream pollution sources, and other concurrent changes. These steps help avoid attributing every observed improvement to a single intervention.

Finally, sanitation should be planned as part of integrated water and environmental management (Van Roon, 2007). Coordination among communities, local governments, utilities, health agencies, and environmental authorities is needed to ensure that local improvements do not shift pollution burdens to other neighbourhoods or downstream ecosystems.

Conclusions

Sanitation has been an important component of settlement organization and remains essential to public health, social inclusion, and environmental protection. Historical examples show that communities invested in water and waste infrastructure, while industrial-era experience demonstrates the importance of combining engineering with epidemiology, public-health governance, and sustained maintenance. In contemporary settings, the benefits of sanitation depend on safe management throughout the service chain, equitable access, and the ability to operate systems over time.

The evidence does not justify treating sanitation as the sole cause of the rise or decline of civilizations, nor does it support broad quantitative claims without transparent sources and comparable indicators. Future research should use clearly documented review methods and verified primary evidence to assess specific pathways and outcomes. For community-based environmental management, the priority is to deliver inclusive, technically appropriate, safely managed, and climate-resilient sanitation services while monitoring both public-health and environmental performance.

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