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Managing WASH infrastructure across local governments: a comparative case study of Indonesian, South African and Swiss municipalities

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Abstract

Purpose – This research aims to analyse the management of public WASH infrastructure across different local governments through the lens of a proposed conceptual framework, and explores specific and common challenges, with the aim to enhance understanding of the current public infrastructure practices and design value-adding strategies that effectively meet societal WASH demands.

Design/methodology/approach – The study employs a comparative case study (CCS) design combined with qualitative content analysis (QCA). Data collection involved semi-structured interviews with public officials and WASH infrastructure managers in eight cities across Indonesia, South Africa and Switzerland. To support the triangulation of findings, supplementary documents were reviewed.

Findings – The study reveals the presence of relatively advanced practices in selected functional pillars of the proposed conceptual framework across the analysed local governments. However, persistent gaps in financial planning and implementation capacities point to a disconnect between strategy formulation and execution. The results further highlight that variations in management practices are more pronounced across functional pillars than across local governments while also indicating the importance of reliable funding systems for supporting long-term infrastructure investment. While funding remains important, effective public WASH infrastructure management ultimately depends on a holistic perspective and interrelated capacities.

Originality/value – This study contextualizes broader discussions to address WASH demands focusing on weaknesses in the management of public infrastructure. It represents the first study to provide cross-contextual comparative analysis of WASH infrastructure management at local government levels. It also develops a conceptual framework for systematically comparing infrastructure management across diverse contexts.

Keywords WASH, Public infrastructure, Public sector management, Public sector governance, Decentralization, Comparative case study

Paper type Research article

1. Introduction

Access to safe water, sanitation, and hygiene (WASH) is essential for human health, well-being, and sustainable development. Water plays a fundamental role in the global development agenda outlined by the Sustainable Development Goals (SDGs), particularly in relation to

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food, energy, and environmental sustainability (UN DESA, 2022). SDG 6 specifically focuses on achieving universal access to clean water and sanitation and access to safe drinking water and sanitation has been recognized by the United Nations General Assembly as a basic human right (UN General Assembly, 2010).

Despite ongoing efforts, limited access to WASH services represents a critical global concern, further intensified by climate change, population growth, and unsustainable water use. In 2020, 26% of the global population (approximately 2 billion people) lacked access to safe drinking water, while 46% (around 3.6 billion people) had no access to adequate sanitation (UNESCO, 2023). Disparities also persist between high-income countries (HICs) and low- and middle-income countries (LMICs). Achieving SDG 6 by 2030 will require a twofold increase in progress for basic drinking water and sanitation, and a threefold increase for basic hygiene. In low-income countries, the required acceleration is even more significant: 6-fold for basic drinking water, 13-fold for basic sanitation, and 16-fold for basic hygiene (WHO/UNICEF JMP, 2023).

Public infrastructure underpins WASH service delivery, making its management increasingly important to meet societal WASH demands (Srinivasan *et al*., 2012; Thacker *et al*., 2018). Infrastructure management can be defined as a set of "actions aimed at the long-term maintenance of the capacity of an infrastructure to provide an efficient service for users, at costs and with impacts that are tolerable for society and the environment" (Le Gat *et al*., 2025, p. 139). Effective public infrastructure management requires sound systems for planning, coordination, integration, and monitoring, as well as mechanisms for compliance enforcement and capacity development (Jiang, 2023; Helmrich *et al*., 2021).

WASH public infrastructure faces particular challenges in local contexts as there is an increasing recognition of the political and administrative benefits of decentralized service delivery. Over the last decades, decentralization reforms have transferred authority for WASH services, including associated infrastructure functions, to lower-tier governments (Stoa, 2014). Extensive WASH property portfolios have been devolved from central to local authorities (Hanis *et al*., 2010, 2011), resulting in disparities in local governments' capacity to manage property ownership and infrastructure oversight (Kgoshi, 2024; Waskitawati *et al*., 2019; Masanyiwa *et al*., 2015). Consequently, the effectiveness of WASH service delivery depends on whether local governments have the capacity, resources, and support to fulfil their infrastructure-related responsibilities (Kgoshi, 2024; Hanis *et al*., 2010).

Despite the proliferation of frameworks for infrastructure management and the growing body of research on WASH infrastructure management (Chaponda *et al*., 2020; Cord *et al*., 2022; Dahal *et al*., 2025; Giglio *et al*., 2018; Horni *et al*., 2020; Kaganova and Nayyar-Stone, 2000; Kumar *et al*., 2023; Nelson *et al*., 2021; Salah and Bisogno, 2023; UN Habitat, 2011), empirical evidence remains limited on how these frameworks are interpreted, adapted, and implemented by the local actors responsible for WASH infrastructure (Brunet and Aubry, 2018). Moreover, while existing studies have identified contextual, financial, and technical challenges in WASH infrastructure management, which differ from those identified in broader infrastructure management research, they largely focus on single cases or countries (Araya and Vasquez, 2022; Cord *et al*., 2022; Dithebe *et al*., 2019; Faust *et al*., 2016; Ruiters and Matji, 2016; Silvestri *et al*., 2018; Van Den Broek and Brown, 2015; Waskitawati *et al*., 2019), rather than undertaking cross-contextual comparative analysis.

Accordingly, there is a need for comprehensive research to understand current management practices of public WASH infrastructure across diverse local contexts. To address this gap, this paper aims to analyse the management of public WASH infrastructure across different local governments through the lens of a proposed conceptual framework, and to explore specific and common challenges related to public WASH infrastructure management. In particular, the two research questions are:

RQ1. How is public WASH infrastructure managed across local governments in Indonesia, South Africa and Switzerland through the lens of a proposed conceptual framework?

RQ2. What are the common and specific challenges in public WASH infrastructure management across local governments in Indonesia, South Africa and Switzerland?

Using a comparative case study approach, the research focuses on eight cities across Indonesia, South Africa, and Switzerland. These countries offer contrasting socio-economic, geographic, and institutional contexts that shape local service delivery. Municipalities were selected based on their mandate and capacity to provide WASH services, as well as their engagement in continuous exchange and peer-learning processes, representing diverse types and sizes. Semi-structured interviews with municipal officials form the core data. The study examines local-level practices rather than national systems, exploring how different local governments address similar WASH management challenges (Stoa, 2014). It specifically considers long-term physical structures managed by local governments. Water services include wells, pipelines, and treatment plants that ensure safe and reliable drinking water. Sanitation services involve facilities such as toilets and sewage systems for safe excreta disposal. Hygiene is examined alongside water and sanitation infrastructure, as it does not rely on standalone public assets.

This study is motivated by the need to advance empirical insights in the management of WASH infrastructure across local governments. It contributes to the literature by developing and applying a conceptual framework that enables a systematic and comparative analysis of infrastructure management practices across diverse contexts. The study provides empirical evidence on current and emerging municipal WASH practices, highlighting both common challenges and context-specific issues. In doing so, it provides actionable insights for policymakers, practitioners, NGOs, and development agencies, supporting the design of strategies that effectively enhance WASH service delivery. Finally, the study is part of an ongoing exchange involving Indonesia, South Africa, and Switzerland, aimed at fostering collaboration and peer learning to strengthen local infrastructure management.

The remaining part is structured as follows. Section 2 reviews the literature on WASH infrastructure management. Section 3 proposes a conceptual framework for examining public infrastructure management. Section 4 outlines the study's research design. Section 5 presents findings on current practices and challenges in managing WASH public infrastructure. Finally, section 6 discusses the results and concludes the study.

2. Literature review

Literature on infrastructure management has expanded substantially over the past decades. A major focus has been the development of frameworks for efficient public asset management, many developed or piloted primarily at the national level, with limited attention to their application at the local level. These frameworks cover transversal and life-cycle aspects, some of which are addressed individually, while others are considered more holistically, including governance, planning, allocation, implementation, operation, maintenance, preservation, monitoring, and disposal (Ahola *et al*., 2014; Chaponda *et al*., 2020; Giglio *et al*., 2018; Hanis *et al*., 2010; Kaganova and Nayyar-Stone, 2000). International organizations have similarly followed this direction, proposing additional infrastructure principles and frameworks (G20, 2020; IMF, 2015, 2022; OECD & IMF, 2019; World Economic Forum, 2024). Comparable attention has also been given to the development of information and accounting frameworks for public asset management (Horni *et al*., 2020; Pallot, 1992; Roje *et al*., 2025; Salah and Bisogno, 2023).

However, there remains limited understanding of how actors translate these frameworks into practice (Brunet and Aubry, 2018). Much of the research has focused on analysing persistent challenges in public asset management, often overlooking the application and contextual adaptation of the proposed frameworks. Literature identifies several recurring factors contributing to poor management of immovable municipal infrastructure, including

insufficient funding, limited technical capacity, weak planning and oversight, absence of by-laws, dependency on grants, corruption, unreliable or non-available data, and political instability (Frolova *et al*., 2016; Hasbi, 2010; Jimenez and Pagano, 2012; Kaganova and Nayyar-Stone, 2000; Mazele and Amoah, 2022; Schraven *et al*., 2011).

In the WASH sector, existing literature on infrastructure management has mobilized either economic, contingency-based, or institutional perspectives. Studies adopting economic perspectives tend to focus on cost estimations or technical assessments related to the provision and access of WASH infrastructure and services (Chaitkin *et al*., 2022; Gnanasekaran *et al*., 2024; Hutton and Varughese, 2016; Mnguni, 2018; Potgieter *et al*., 2021). Contingency-based approaches emphasize the contextual choices and strategies that influence infrastructure management under certain settings or circumstances, such as natural disasters or technological changes (Dahal *et al*., 2025; Johannessen *et al*., 2013; Kumar *et al*., 2023). Institutional perspectives highlight how formal and informal rules, along with organizational arrangements, shape infrastructure management and service delivery, including community participation in WASH infrastructure use (Cord *et al*., 2022; Jiménez *et al*., 2019; Moriarty *et al*., 2013; Nelson *et al*., 2021; Novotný *et al*., 2018).

Beyond these theoretical perspectives, other studies have focused on specific challenges in WASH infrastructure management, which differ from those identified in broader infrastructure management literature. These sector-specific challenges can be broadly categorized into three groups: contextual, financial, and technical. Studies on contextual challenges examine the complexities of WASH infrastructure management in resource-constrained or unstable environments, such as informal settlements, remote communities, or emergency contexts (Cord *et al*., 2022; Moriarty *et al*., 2013; Rhodes-Dicker *et al*., 2022; Silvestri *et al*., 2018; Van Den Broek and Brown, 2015). Studies on financial challenges increasingly emphasize the persistent funding gap in WASH investments and the strategies for addressing those financing constraints (Bose *et al*., 2024; Chandratreya, 2023; Jiang, 2023; Ruiters and Matji, 2016; Senyakoe, 2011; Waskitawati *et al*., 2019). Reports from international organizations, such as the World Bank and the Organization for Economic Co-operation and Development (OECD), offer additional insights from development practice on mobilizing WASH finance (OECD, 2018; Pories *et al*., 2019; World Bank, 2017). Fewer studies have examined technical challenges (Dithebe *et al*., 2019; Faust *et al*., 2016; Johannessen *et al*., 2014; Nelson *et al*., 2021), although recent work has begun addressing issues such as infrastructure integration across systems (Araya and Vasquez, 2022; Le Gat *et al*., 2025).

Despite the proliferation of frameworks for infrastructure management and the growing body of research on WASH infrastructure management, empirical evidence remains limited on how these frameworks are interpreted, adapted, and implemented by local actors responsible for WASH infrastructure. Additionally, although existing studies have identified contextual, financial, and technical challenges in WASH infrastructure management, they largely focus on single cases or a single country, limiting opportunities for cross-contextual comparison (Araya and Vasquez, 2022; Cord *et al*., 2022; Dithebe *et al*., 2019; Faust *et al*., 2016; Ruiters and Matji, 2016; Silvestri *et al*., 2018; Van Den Broek and Brown, 2015; Waskitawati *et al*., 2019).

3. Conceptual framework

The conceptual framework serves as the analytical lens for this comparative case study. As noted by Llewelyn (2003), conceptual frameworks play a critical role to drive empirical analysis within qualitative research. Specifically, Llewelyn (2003, p. 667) identifies five levels of theorization, ranging from "Level One theories," which are grounded in immediate experience, to "Level Five theories," which address broad and enduring aspects of social life. Within this hierarchy, conceptual frameworks are classified as "Level Three theories," reflecting their "theoretical significance" as a "fundamental tool" for observing and

interpreting empirical phenomena in the social sciences (Llewelyn, 2003, p. 672), particularly in management and accounting disciplines (Llewelyn, 2003, p. 674).

The conceptual framework is informed by recent scholarly contributions on public infrastructure management. It builds on the premise that efficient and effective management of public infrastructure in general – and WASH infrastructure in particular - rests on four interrelated pillars, which are embedded and shaped by the overarching institutional context. Figure 1 provides a visual representation of the proposed conceptual framework.

(1) Asset planning ensures that WASH infrastructure is fiscally sustainable, properly appraised, and effectively coordinated across sectors, levels of government, and users, so that infrastructure can meet current and future service demands efficiently and equitably (e.g. Chaponda *et al*., 2020; OECD, 2020);

(2) Financial planning allows the allocation of public investment to the most productive WASH infrastructure projects through comprehensive, unified, medium-term budgeting and the use of objective criteria for selecting funding sources, with the goal of maximizing the value and impact of public resources for service delivery (e.g. Chaponda *et al*., 2020; OECD, 2020);

(3) Project implementation ensures that WASH infrastructure projects are effectively and timely managed throughout their implementation, aiming to deliver functional, reliable, and high-quality infrastructure for service delivery (e.g. Chaponda *et al*., 2020; OECD, 2020);

(4) Asset reporting contributes to the identification and resolution of challenges, facilitating informed decision-making, continuous learning, and accountability in WASH infrastructure management (Grubišić *et al*., 2009; Horni *et al*., 2020; Roje *et al*., 2025; Salah and Bisogno, 2023).

While asset planning, financial planning and project implementation are already covered by some international frameworks (Chaponda *et al*., 2020; IMF, 2022), these frameworks usually do not explicitly account for asset reporting, which is, however, considered an important source of information for decision-making (e.g. Roje *et al*., 2025; Salah and Bisogno, 2023; Horni *et al*., 2020). For this reason, we explicitly added a pillar on asset reporting. While this paper specifically examines how WASH infrastructure is managed across local governments,

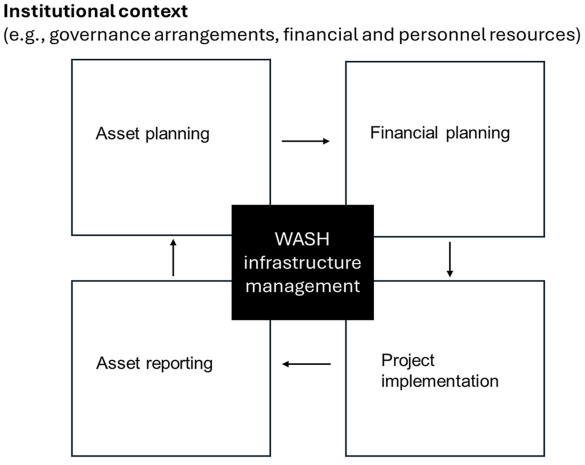

Figure 1. Conceptual framework. Source: Own illustration

the framework also recognizes that infrastructure management and public service delivery are embedded in broader institutional contexts. These contexts are shaped by distinct political, administrative, and financial arrangements across jurisdictions, which may influence management practices and outcomes (Bolleyer and Thorlakson, 2012; Canare, 2021; Chaponda *et al*., 2020; Faguet, 2021; Hegele *et al*., 2024; Jiménez *et al*., 2019).

Table 1 provides a detailed overview of all pillars and elements of the conceptual framework, including the key sources that informed its development. For each element, a brief description is provided together with information on how it is analysed across cases. Given the qualitative nature of the underlying data, the comparison is interpretative rather than normative. The analysis does not aim to generate rankings or quantitative assessment scores but rather to identify patterns, gaps, and context-specific differences. The comparison follows a structured yet qualitative logic, focusing on the extent to which each element of the conceptual framework is present, institutionalized, or discussed within the respective municipal contexts. For each element, we apply a meaningful set of features to systematically capture differences and similarities as well as provide illustrative quotes in the results section to showcase patterns, gaps or context-specific differences. In particular, the following features are used:

(1) Existence: Availability or non-availability of a specific issue/element (*yes/no).*

(2) Institutionalization: Perceived level of institutionalization based on qualitative evidence (*fully institutionalized, partly institutionalized, not institutionalized*).

(3) Extent: Degree to which quantitative or qualitative information, internal capacities, or resources are available (*comprehensive, moderate, or limited*)

(4) Periodicity: Temporal gradation for elements where cyclical or time-bound processes are critical.

(5) Open categories: Qualitative responses for elements where a range of possible configurations exists (e.g. funding mix).

(6) No answer: Cases where interviewees did not provide information on the respective element.

4. Research design

4.1 Study setting

This exploratory study adopts a qualitative design and is situated within the interpretivist paradigm (Guba and Lincoln, 2005). The research strategy employed is a Comparative Case Study (CCS) that addresses different dimensions and characteristics of WASH infrastructure practices across the analysed local governments. This paper focuses on empirical practices to support processes of discovery and problem-solving (Bartlett and Vavrus, 2017). The CCS enables an exploration of how local governments, in different contexts facing diverse social or political challenges, may nonetheless address comparable issues through similar measures (Carney, 2009).

4.2 Unit of analysis

The unit of analysis (Bartlett and Vavrus, 2017) comprises local government level in Indonesia, South Africa, and Switzerland. These countries were selected because they offer contrasting socio-economic conditions, geographic characteristics, and institutional contexts. As decentralization initiatives have transferred responsibilities to subnational levels, local authorities are now mainly responsible for WASH service delivery. Accordingly, the study selects municipalities that hold the mandate and possess the institutional capacity to provide WASH services, while also actively engaging in continuous exchanges and peer-learning

Table 1. Elements of the conceptual framework

Pillars and elements	Purpose	Features	Selected references
Asset planning			
Multi-year investment programs	Existence of longer-term infrastructure investment planning	Existence	OECD (2020), Chaponda *et al.* (2020), Allen *et al.* (2020), Horni *et al.* (2020)
Investment appraisal	Existence of investment prioritization based on defined/ formal criteria (e.g. economic, social, fiscal, environmental)	Existence	OECD (2020), Chaponda *et al.* (2020), Horni *et al.* (2020)
Maintenance planning	Institutionalization of medium to longer-term planning of maintenance needs	Institutionalization	OECD (2020), Chaponda *et al.* (2020), Horni *et al.* (2020)
Public and stakeholder participation	Institutionalization of public participation in infrastructure planning and/or design	Institutionalization	Nelson *et al.* (2021), OECD (2020), Waskitawati *et al.* (2019), Bice *et al.* (2019), Masanyiwa *et al.* (2015)
Financial planning			
Integrated planning and budgeting	Existence of integrated infrastructure planning and financing frameworks (e.g. medium-term budget frameworks)	Existence	OECD (2020), Chaponda *et al.* (2020), Allen *et al.* (2020), Horni *et al.* (2020)
Funding sources	Type of funding for capital investments and/or maintenance spending	Open	OECD (2020)
Funding gap	Existence of a perceived funding gap to fund capital and maintenance spending	Existence	OECD (2020), Chaponda *et al.* (2020), Faguet (2021)
Maintenance funds	Existence of dedicated maintenance funding/fund	Existence	Blazey *et al.* (2020), Chaponda *et al.* (2020)
Project implementation			
Internal implementation capacities (HR)	Perceived extent of internal project implementation capacities (human-resources)	Extent	Chaponda *et al.* (2020), Horni *et al.* (2020), Monteiro *et al.* (2020)
Formal procurement process	Availability of a formal and competitive tendering process	Existence	OECD (2020), Chaponda *et al.* (2020), Horni *et al.* (2020), Talierco and Estrada (2020)
Oversight of external service providers	Oversight and quality assurance processes for outsourced activities	Institutionalization	Talierco and Estrada (2020), Chaponda *et al.* (2020)
Asset reporting			
Comprehensiveness of asset register	Asset register includes legal, physical and financial information of infrastructure assets in asset registers	Extent	Roje *et al.* (2025), Salah and Bisogno (2023), OECD (2020), Horni *et al.* (2020), Grubišić *et al.* (2009)
Update of asset information	Regular update/reconciliation of asset registers	Periodicity	Roje *et al.* (2025), Horni *et al.* (2020), Salah and Bisogno (2023), Grubišić *et al.* (2009)
Recognition and measurement of assets in balance sheet	Recognition and measurement of assets in balance sheets and financial reports	Extent	Salah and Bisogno (2023), Horni *et al.* (2020), Grubišić *et al.* (2009)
Depreciation policy	Depreciation policy (e.g. useful life)	Open	Salah and Bisogno (2023), Horni *et al.* (2020), Grubišić *et al.* (2009)

activities. The selected cases represent diverse profiles in terms of type (capitals, industrial, and metropolitan) and size (small, medium, and large). In particular, the selected local governments are two cities in Indonesia, three in South Africa, and three in Switzerland. A third Indonesian city was targeted for inclusion, but no response was obtained. The participating municipalities were selected through the networks of the Swiss State Secretariat for Economic Affairs (SECO), the World Bank, and the International Budget Partnership (IBP), all of which maintain close engagement with local governments in public sector asset management.

4.3 National contexts

Local governments operate within distinct national and institutional contexts that shape WASH governance arrangements, financing models, service delivery structures, and infrastructure management practices (WHO/UNICEF JMP, 2023; Cord *et al*., 2022; Jiménez *et al*., 2019; Moriarty *et al*., 2013). The following section therefore provides a brief overview of the national and institutional contexts.

4.3.1 Indonesia. Indonesia is a middle income, decentralized unitary state consisting of thousands of islands (an extensive archipelago). Indonesia's public administration is structured across four levels: the central government, 38 provincial governments, 514 cities and districts, and approximately 84,200 village governments. Since the 2001 decentralization reforms, infrastructure and basic service responsibilities have largely been devolved to subnational governments, while the central government continues to bear most of the costs. The 2022 intergovernmental finance law introduced two guiding principles: optimizing local governments' revenue and spending quality, and aligning fiscal priorities between central and local levels (Pasaribu, 2022). Municipal governments often delegate infrastructure management to regionally owned enterprises (ROE) to increase efficiency and financial flexibility. In rural districts, a community-based approach is used, promoting participatory planning and local management of WASH services.

4.3.2 South Africa. South Africa is an upper-middle-income, decentralized unitary state with varied topography. South Africa operates under a three-tier system of government: the central government, 9 provinces, and 257 municipalities (South Africa, 2024). Responsibility for WASH is shared across all three levels. The Department of Water and Sanitation (DWS) at the central level sets legislation, policies and standards, manages water resources through nine water boards, and monitors the performance of provincial and local governments in WASH service delivery (DWS, 2024). National Treasury grants also support provinces and municipalities. Provinces provide funding, technical assistance, and capacity building, and monitor municipal performance, while facilitating cooperation between district and local municipalities. Municipalities, as water services authorities, are directly responsible for delivering WASH services, including the development, maintenance, and operation of treatment facilities and service planning (Water Services Act 108 of 1997, 1997).

4.3.3 Switzerland. Switzerland is a high-income, landlocked federal state. Switzerland's public administration has three levels: the federal government, 26 cantonal governments, and around 2.150 municipalities. Its governance is shaped by strong federalism and the principle of subsidiarity, which applies at all administrative levels. The principle of subsidiarity ensures that decision-making and service provision occur at the most local and competent level of government (Fuchs *et al*., 2015). Higher levels of government should only intervene when lower levels are unable to fulfil a task effectively. In the WASH sector, this means that local governments are primarily responsible for WASH service provision and infrastructure management (Swiss Federal Office for the Environment, 2025). Municipalities also have flexibility in selecting governance models for WASH service provision (Fuchs *et al*., 2015).

4.4 Data and methods

Based on the conceptual framework developed to enable a systematic comparison across cases, an interview guide was designed to address all key pillars of the analysis. 14 semi-structured interviews with selected municipal officials constitute the core of the CCS approach employed in this research. All interviews were conducted online via Microsoft Teams and lasted between 60 and 90 min. The interviews were carried out until saturation was reached. To ensure confidentiality, it was agreed with the interviewees that their identities would remain anonymized. The interviews were transcribed and coded using MAXQDA qualitative analysis software (Version 24.6.0). A total of 312 codes were assigned, including two levels of sub-codes (cf. Codebook in Annex). Table 2 presents further information on the interviews conducted.

To address the research questions, this study employed the Qualitative Content Analysis (QCA) following Mayring and Fenzl (2019). A combination of deductive and inductive coding was applied. In the first phase, a strictly deductive approach was applied, deriving coding categories from the research questions (RQ1, RQ2) and the conceptual framework presented in Figure 2. The four pillars of the conceptual framework served as the foundation for the initial version of the codebook and are marked with "(D)" to indicate codes derived deductively from the framework. In the second phase, an inductive coding approach was employed to identify emerging answer patterns, which were subsequently integrated into the codebook (marked with "I" in the codebook). Overall, inductive coding did not significantly adjust the deductive codebook but led to the addition of a few second-level codes, particularly in relation to specific challenges in WASH infrastructure management (RQ2). For consistency, coding was conducted by a single researcher. To ensure validity and reliability, a peer debriefing process was undertaken, where one of the co-authors reviewed and challenged coding decisions. However, no formal intercoder reliability tests were conducted.

Additionally, a data triangulation process was conducted using supplementary sources, such as official reports, strategy documents, accounting policies and financial reports, as outlined in Table 2. Semi-structured interviews were triangulated with documentary evidence to compare public WASH infrastructure management practices across cases and validate interview findings. Additional documents were also used to address information gaps, such as accounting manuals to compare or clarify depreciation policies, and financial reports to validate funding gaps in Swiss municipalities. Considering contextual differences across countries, WASH infrastructure–related supplementary documents were not available for all cities. Instead, the collection was adapted to each country's institutional environment. In Switzerland, open-access information policies facilitated the collection of documents related to investment and maintenance strategies. In contrast, access to official documentation is more restricted in the other two countries. In South Africa, the Open Budget Survey was therefore used as a complementary source, as it evaluates budget transparency, public participation, and oversight. In Indonesia, relevant information was obtained only for one municipality, while no official documents were accessible for the other. Although not formally coded, these documents primarily served as contextual and corroborative sources to support the comparison and interpretation of findings. The overall research design is presented in Figure 2.

5. Results

5.1 Management of WASH infrastructure in local government levels

The first section addresses the first research question (RQ1) which focused on how public WASH infrastructure is managed across local government levels. The study aims to answer this question through the lens of the conceptual framework (cf. Figure 1), examining its four key pillars to provide a structured understanding of the management practices.

Table 2. Description of cases

Case	City size	Type	Country	WASH service providers	Number of interview(s) (n = 14)	Position of interviewees	Supplementary data
A	Small < 1M	Cantonal capital and touristic centre	CH	Government agency	2	CFO Municipal WASH Infrastructure/ Head of Municipal WASH infrastructure	Internal maintenance investment strategy, and accounting policies documents
B	Small < 1M	Economic centre and part of metropolitan region	CH	Government entity (for water) and intermunicipal association (for sanitation)	1	Deputy CFO Municipal WASH Infrastructure	Internal maintenance, investment strategy, and accounting policies documents
C	Small < 1M	Economic centre and part of metropolitan region	CH	Public corporation (for water) and intermunicipal association (for sanitation)	2	Head of Municipal WASH infrastructure	Internal maintenance, investment strategy, and accounting policies documents
D	Large > 1M	Coastal metropolitan city and economic centre	ZA	Government entity	1	Director of Municipal Corporate Projects, Programs, and Portfolio	Accounting policies and the international Budget Partnership Survey on planning and budgeting for repairs and maintenance (2024)
E	Large > 1M	Metropolitan city and industrial centre	ZA	Public corporation	1	Head of the Municipal Strategic Portfolio Management Office	Accounting policies and the international Budget Partnership Survey on planning and budgeting for repairs and maintenance (2024)
F	Large > 1M	Coastal city and part of metropolitan region	ZA	Government entity	1	Senior Manager of the Municipal Infrastructure Asset Management	Accounting policies and the international Budget Partnership Survey on planning and budgeting for repairs and maintenance (2024)
G	Large > 1M	Metropolitan economic centre	ID	Government entity	5	Head of Strategic Planning and Development Financing Division/ Technical Director of WASH ROE/ Three staff members of the Water Resource Agency	Accounting policies and the Pathways to Integrated Urban Water Management for Greater Jakarta (World Bank, 2017)
H	Small < 1M	Agricultural and agro-industrial city	ID	Regional water company and local wastewater treatment plans (managed by individuals or communities)	1	Secretary of Regional Planning agency	None

Source(s): Own table

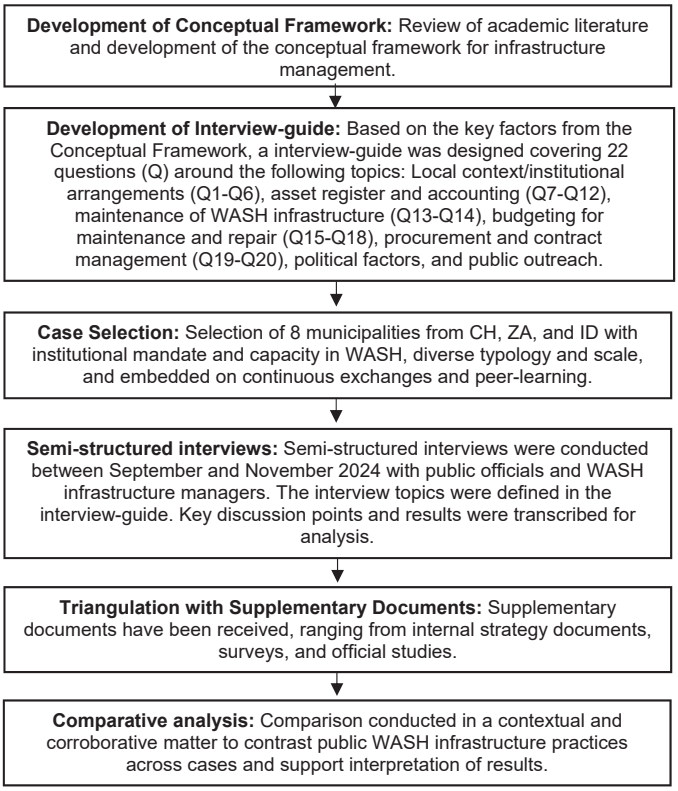

Figure 2. Research design. Source: Own illustration

5.1.1 Asset planning. Although asset planning processes in WASH infrastructure management vary across cities, empirical findings suggest that the majority have incorporated key elements that enable longer-term, life cycle-oriented management of WASH infrastructure. While some country-level differences are observable, they do not follow a systematic pattern.

With respect to investment planning, seven out of eight cities report having multi-year investment programs, although terminology, content, and planning cycles of these programs differ across jurisdictions (see Table 3). In Switzerland, these programs are called “General Drainage Plans (GDP)” (Cases A, B, C) whereas South African cities refer to instruments such as “Strategic Asset Management Plans” (Cases D, F), and “Future Growth Plans” (Case E). In Indonesia, strategic direction is primarily derived from “Regional Development Plans” (Cases G, H).

Most cities report similar criteria which guide the development of investment programs, including legal requirements, the physical condition of assets, and opportunities to create synergies with other construction projects. Interestingly, the degree of political influence appears to vary across jurisdictions. The following two statements illustrate contrasting levels of political engagement within investment planning:

> Political influence is restricted by financial law. Therefore, WASH infrastructure investments are less contested than investments in other policy areas (Case C, Switzerland).

Table 3. Comparative results

Pillars and indicators	Case A CH	Case B CH	Case C CH	Case D ZA	Case E ZA	Case F ZA	Case G IN	Case H IN
Asset planning								
Multi-year investment programs	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Formal process for investment prioritization	Yes	Yes	Yes	Yes	Yes	No	No	Yes
Monitoring and maintenance planning	Full	Full	Full	Full	Partial	Partial	Full	Partial
Public and stakeholder participation	Partial	Partial	Partial	Full	Full	Partial	Full	Full
Financial planning								
Integrated planning and budgeting	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Funding sources	Tariffs	Tariffs	Tariffs	Tariffs	Tariffs, Grants, Equitable shares	Tariffs, Grants, Equitable shares	Tariffs, Transfers	Transfers
Funding gap	No	No	No	Yes	Yes	Yes	Yes	Yes
Maintenance funding/ funds	Yes	Yes	Yes	Yes	No	No	No	No
Project implementation								
Internal implementation capacities (HR)	Moderate	Moderate	Comprehensive	Limited	Moderate	Limited	Limited	Limited
Formal procurement process	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No answer

(*continued*)

Table 3. Continued

Pillars and indicators	Case A CH	Case B CH	Case C CH	Case D ZA	Case E ZA	Case F ZA	Case G IN	Case H IN
Oversight of external service-providers	Partial	Partial	Full	Full	Full	Partial	Full	Partial
Asset reporting								
Comprehensiveness of asset register	Comprehensive	Comprehensive	Comprehensive	Partial	Comprehensive	basic	Comprehensive	No answer
Update of asset information	Periodic	Annual	Annual	Periodic	Annual	No regular update	Annual	annual
Recognition and measurement of assets in balance sheet	Comprehensive	Comprehensive	Comprehensive	Comprehensive	Comprehensive	Limited	Comprehensive	Moderate
Depreciation policy	Useful life	Useful life	Useful life	Useful life	Useful life	Useful life	Useful life	Useful life

> Investment priorities for public infrastructure, particularly for essential services like sanitation and drinking water, are heavily influenced by overarching considerations of regional leaders. (Case G, Indonesia).

With respect to maintenance planning, five out of eight cities report having adopted institutionalized systems and processes to determine future maintenance needs thereby considering a combined set of criteria (see Table 3).

> The process for determining major improvements and prioritization is based on condition, performance, and age. Furthermore, the master plan for future growth is also considered during this process. (Case E, South Africa).

However, the large and ageing infrastructure presents a major challenge for proactive maintenance activities across cities. Furthermore, some cities face missing information and a lack of available data needed for proactive maintenance planning.

> The largest obstacle in maintenance is the underground pipeline network, which ranges in age from several decades to over 100 years. This aging infrastructure makes it difficult to detect and repair leaks and maintain a stable water supply in areas far from water treatment installations. (Case G, Indonesia)

> The maintenance process is not driven by data or planning. Maintenance planning is based on advancing historic values or on emergency needs. (Case F, South Africa)

Finally, empirical findings reveal different levels of institutionalization of public participation and community engagement. In Switzerland, public participation is partly institutionalized, primarily focusing on media releases to inform the public or public signs to mark construction sites (Cases A, B, C).

In contrast, Indonesian and South African cities report stronger forms of public participation within WASH investment and maintenance planning. In Indonesia, public participation is institutionalized through "Musrenbang", which are regional development planning forums held at district, sub-district, and village levels (Cases G, H). These forums provide a platform for citizens to engage with public officials, learn about ongoing developments, and contribute their perspectives. With respect to smaller and more remote islands, public participation does not stop at the level of planning, but also develops into broader community-based management, which is considered very important.

> The community-based management, where local groups are involved and responsible, is key to success. Self-reliance among communities, along with support from village governments, is crucial for effective infrastructure services. (Case H, Indonesia)

Also, South African cities emphasize the importance of community-based projects particularly in the context of informal settlements (Cases D, E, F) where law requires a city to structure and manage its administration and budgeting and planning processes to give priority to the basic needs of the community.

5.1.2 Financial planning. Empirical findings reveal homogenous financial planning systems but greater divergence with respect to funding sources as well as perceived funding gaps.

With respect to financial planning, seven out of eight cities report having integrated planning and budgeting systems, such as medium-term expenditure frameworks (see Table 3). The integration of strategic and financial planning of WASH infrastructure services is an important tool for efficient and effective service delivery, because it translates strategic ambitions into financial realities.

> Alongside long-term investment planning, medium-term financial planning is a very important management instrument. It is designed for a four-year period and connects planned services with the corresponding budget. (Case C, Switzerland)

However, one municipality appears to face challenges in establishing integrated planning and budgeting systems. The same municipality also reported difficulties in developing a longer-term investment program. (see Table 3).

> The cause of many of the challenges is not technical maintenance processes but are rooted in the integrated governance and management control of the city's key processes and functions, including strategy formulation and budgeting. (Case F, South Africa).

Substantial differences seem to exist with respect to funding models and perceived funding gaps. Swiss cities report that investments in and maintenance of WASH infrastructure are fully financed through tariffs (Cases A, B, C).

> Water and wastewater services are funded through user fees and are not part of the overall tax base. Because they are fee-based, they are not subject to political competition, as seen in other policy areas. (Case A, Switzerland).

These tariffs are required to ensure full cost recovery and are allocated to special-purpose funds and strictly earmarked for WASH infrastructure expenditures. Special-purpose funds cannot be diverted to other policy areas (Cases A, B, C). User fees are calculated separately for both water and wastewater services, based on anticipated maintenance needs and planned capital investments. For Swiss cities, this funding model appears to function effectively, as all cases report having sufficient resources for planned investments and maintenance activities.

In contrast, funding models in Indonesia and South Africa are more mixed and seem to be under pressure. In many cases, tariffs do not appear to cover the required expenditures, leading cities to rely on additional sources such as transfers from higher levels of government. This reliance makes cities dependent on overarching political decisions. Moreover, even these supplementary funds are perceived as insufficient, as all South African and Indonesian cities unanimously report facing a funding gap (Table 3).

> Sufficient budget is the most pressing challenge. Operating budget is constantly under pressure. (Case D, South Africa)

> The subnational government still requires support from the central government, particularly in funding, to achieve comprehensive WASH service coverage. (Case G, Indonesia).

The lack of sufficient funding has adverse consequences, as it constrains proactive maintenance. As a result, cities face more frequent and costly emergency interventions.

> High levels of Non-Revenue Water, primarily from physical losses, are driven by inefficiencies and aging infrastructure. (Case E, South Africa)

> More funds are allocated to infrastructure repairs than to routine, proactive maintenance. In the sanitation sector, repair costs can be 2–3 times higher than maintenance costs. (Case G, Indonesia).

> Ideally, maintenance plans are based on the asset's service life or remaining capacity. However, budget constraints require prioritization of projects. Therefore, more budget is spent on infrastructure repairs than on routine, proactive maintenance. (Case H, Indonesia)

5.1.3 Project implementation. Seven out of eight cities report a lack of internal resources and capabilities, which poses risks to both timely project execution and the maintenance of quality standards. As a consequence, all cities rely on outsourcing to third parties, though they appear to employ different mechanisms for monitoring and oversight.

> A major challenge is the timely execution of planned large-scale investments. Projects are often delayed due to a lack of human resources or prolonged administrative processes. (Case B, Switzerland)

> Limited staff capacity and capabilities within the existing team pose challenges. (Case G, Indonesia)

The perceived lack of internal resources does not appear to be a direct consequence of budget gaps, as Swiss cities also report shortages of internal capacity for project implementation. One Swiss city (Case B) reported that limiting internal project implementation resources functions as an indirect cutback strategy by the finance department, since the level of internal resources directly correlates with maintenance and capital spending. Consequently, reducing human resources also leads to lower infrastructure expenditures.

Literature discusses additional reasons for constrained internal capabilities, stemming from both internal factors (e.g. weak recruitment and retention strategies) and external factors (e.g. competition for talent) (Knies *et al*., 2024). Overall, it does not seem to be a problem specific to WASH infrastructure management, but rather a broader issue in public management (e.g. Andrews *et al*., 2017).

Staff shortages can slow down and complicate project execution and make it necessary to outsource tasks. All cities report that they depend on third-party assistance for project execution. In some instances, outsourcing accounts for up to 90% of the total budget (Case C). However, extensive outsourcing presents additional challenges.

First, it raises corruption risks, prompting questions about how such risks are mitigated, particularly through compliance with regulations of the World Trade Organization (WTO). Cities appear to address this issue through various mitigation strategies, including the procurement of larger framework contracts to ensure compliance while reducing procurement costs (Cases D, E), as well as establishing distinct procurement units to ensure compliance (Cases A, B, C, D, G, H).

> There are numerous framework contracts that are being used. There are internal procurement processes as well as engineers and project managers who oversee these contracts and works. (Case D, South Africa)

Second, outsourcing brings concerns about contract and procurement management, particularly regarding the alignment of procurement plans with financial and technical planning. Two cities explicitly identify the need for better integration of contractual, financial, and technical information to increase efficiency (Cases A, H)

> Maintenance planning is not well integrated or aligned with the procurement planning. (Case H, Indonesia)

Finally, outsourcing poses challenges related to quality assurance and oversight, as municipalities must ensure that outsourced projects meet expected standards through effective monitoring mechanisms. The results indicate that quality assurance is approached differently across cities. Some municipalities rely more on informal and ad-hoc quality control measures (Case C), whereas the majority appear to have formalized quality assurance processes in place (Cases E, F, G, H).

5.1.4 Asset reporting. Asset information appears to be relatively comprehensive across cities, particularly with regard to technical data, most notably Geographic Information System (GIS) records. GIS datasets primarily include spatial information and technical details about WASH infrastructure.

> Technical (GIS) asset registers are updated on a weekly basis. They contain information about the geographical location, physical condition or legal information of the assets. (Case B, Switzerland)

> The technical asset register carries information relating to asset descriptions, asset classes, current replacement value, condition, remaining useful life, performance attributes, which are essential to inform the failure modes that are required to perform proper lifecycle asset planning. (Case E, South Africa)

Interestingly, GIS data often prove to be more comprehensive than asset registers maintained for accounting purposes. While GIS databases are typically updated frequently and in response to specific incidents, asset registers are reconciled periodically usually on an annual basis, and in some cases more often. Five out of eight cities report having comprehensive asset registers in the sense that they reconcile their GIS databases with asset registers at least once per year (see Table 3).

> The asset register is updated annually through incorporating the new assets from completed projects and de-recognizing the replaced assets. (Case E, South Africa)

Nevertheless, reconciling GIS data with asset (accounting) registers remains a challenge in some cities, particularly in South Africa. For example, one municipality (Case D) reports the absence of proper reconciliation mechanisms and has established a task force to align GIS data with both asset registers and insurance records.

> A task team has been established to attempt to reconcile the financial and technical and insurance registers. Unfortunately, we have been advised to keep spreadsheets as SAP does not integrate financial and technical records. (Case D, South Africa).

Another municipality (Case F) acknowledges that its GIS data and asset registers are currently not aligned. Such deficiencies in reliable asset information negatively affect both asset management and financial planning.

> But the lack of systems to drive data led decision making is hampering efforts to institutionalize the preparation of these documents annually and to integrate them into the annual budget and planning process plan. (Case F, South Africa)

Also in Indonesia, one municipality faces challenges in recognizing and measuring infrastructure assets within the balance sheet:

> Currently, the local government lacks a comprehensive understanding of how to calculate asset depreciation. (Case H, Indonesia)

5.2 Challenges in WASH asset management

Table 4 summarizes both common and context-specific challenges in WASH asset management across the examined countries. These challenges were partly derived from the previous section, which addressed and compared current WASH infrastructure management practices in response to RQ1 (cf. Table 3). Key issues such as ageing infrastructure, funding gaps, and limited internal project management capacities have already been outlined earlier and are now synthesized in Table 4.

In addition, the table captures further, often highly context-specific, challenges mentioned during the interviews. These include (1) integrating climate considerations into asset planning, (2) developing new approaches for tariff setting in financial planning, and (3) advancing technological innovations in project implementation.

Regarding sustainability considerations, two Swiss cities (Cases A, B) expressed concerns about the future impacts of climate change on WASH infrastructure, as illustrated by the following quote:

> Heavy rainfall events seem to increase in the future. However, the capacity of the underground pipe network cannot be easily adjusted, as it is based on historical infrastructure from the 50ties. (Case C, Switzerland)

Interestingly, sustainability concerns were not comprehensively addressed by the interviewed cities in Indonesia and South Africa. Only one South African municipality reported significant challenges in managing pipeline pressure *"as a result of past droughts"* (Case D), while the others did not explicitly mention climate-related issues.

Table 4. Challenges in WASH-infrastructure management

Pillars	Switzerland	South Africa	Indonesia
Asset planning	• Ageing infrastructure (Cases A, B, C) • Adverse impact of climate change (increasing rainfall events) on pipe networks (Cases A, B) • Prolonged political and administrative processes (Case B)	• Ageing infrastructure without maintenance and large infrastructure backlog (Cases E) • Problems with air pressure management due to droughts (Case D) • Integration of key management systems and processes (Case F)	• Ageing infrastructure without maintenance and large infrastructure backlog (Cases G, H) • Integration of key management systems and processes (Case H)
Financial planning	• Increased pressures to increase tariffs (Cases A, B) • New methods to set (incentive-based) tariffs (Case C)	• Funding gaps (Cases D, E, F) • High non-revenue water due to physical water losses within underground pipe networks due to non-replacements (Case E)	• Funding gaps (Cases G, H) • Finding the right methods to calculate and set tariffs (G)
Project implementation	• Strong dependence on outsourcing due to a lack of internal capacities (Cases B, C) • Standardized processes for oversight of external service providers (Case A, B) • Lack of innovation in materials for carbon neutral constructions (Cases A, B) • Increasing prices for construction materials (Case B)	• Strong dependence on outsourcing due to a lack of internal capacities (Cases D, E) • Long and prolonged procurement processes (Case E) • Lack of technological advancements in maintenance engineering (Case E)	• Strong dependence on outsourcing due to a lack of internal capacities (Cases G, H) • Insufficient water filters to address ongoing water quality concerns (Case H) • Lack of technological advancements in maintenance engineering (Case G, H)
Asset reporting	*No specific challenges reported*	• Reconciliation of asset/ accounting information (Case F) • Lack of information for decision-making (Case F)	• Lack of information to calculate asset depreciation (Case H)

Regarding financial planning, cities across contexts face similar challenges in setting appropriate tariffs, albeit for different reasons. In Cases A and B (Switzerland) and Case G (Indonesia), municipalities experience strong - often highly politicized - pressures to raise tariffs in response to future investment needs. In Case C (Switzerland), tariff adjustments primarily aim to incentivize citizens to reduce sealed surface areas, thereby alleviating pressure on the underground drainage network. In Case E (South Africa), high levels of non-revenue water resulting from pipe leakages exacerbate existing funding shortages and further complicate tariff setting.

> A key challenge lies in developing new incentive-based tariff systems that encourage citizens to reduce sealed and concreted surface areas, thereby easing pressure on underground pipe networks (Case C, Switzerland)

Finally, several cities (Cases A, B, E, G, and H) reported a lack of technological advancement in the areas of construction and maintenance. This includes challenges in adopting more carbon-neutral construction methods as well as in improving the efficiency of maintenance engineering.

6. Discussion and conclusion

With this study, we sought to analyse the management of WASH infrastructure (RQ1) and explore specific and common challenges related to public WASH infrastructure management across local governments in Indonesia, South Africa, and Switzerland (RQ2). Our findings reveal the presence of relatively advanced practices in selected functional pillars of the proposed conceptual framework. However, persistent gaps in financial planning and implementation capacities point to a disconnect between strategy formulation and execution. The results further highlight the importance of reliable funding systems for supporting long-term infrastructure investment, while also indicating that variations in management practices are more pronounced across functional pillars than across local governments. In the following, each point is discussed in more detail.

First, the comparative analysis identifies comparable practices in public WASH infrastructure management with respect to some elements of the conceptual framework. Across most cases, relatively sophisticated practices are observed in the area of asset planning. Several local governments make use of multi-year investment programmes (Case A, B, C, D, E, G, H), which support a more strategic allocation of resources and facilitate the anticipation of medium-to long-term infrastructure needs. In addition, the existence of formal procedures for investment prioritization (Case A, B, C, D, H) indicates an effort to structure decision-making processes and to enhance transparency in the selection of capital projects. These results resonate with recent findings in the literature (e.g. Chaponda *et al.*, 2020; OECD, 2020). Similarly, asset reporting practices tend to be comparatively well developed. Many local governments maintain asset registers (Case A, B, C, E, G), which contribute to improved information availability for planning, monitoring, and accountability purposes. Furthermore, the recognition of WASH assets in balance sheets (Case A, B, C, D, E, G) supports greater financial visibility of infrastructure resources (Grubišić *et al.*, 2009; Horni *et al.*, 2020; Roje *et al.*, 2025; Salah and Bisogno, 2023). Together, these elements indicate a certain degree of alignment with internationally recognized practices in public financial management and respond to increasing stakeholder expectations regarding transparency and accountability (OECD, 2020).

Second, despite the presence of comparable practices with respect to certain elements of the conceptual framework, the analysis also reveals a gap between current practices in the management of WASH infrastructure across the analysed local governments and the proposed conceptual framework. Particular practices seem to be unevenly developed (e.g. financial planning and project implementation) across local governments, which limits a holistic WASH infrastructure management approach as proposed in the conceptual framework. In particular, a majority of local governments face challenges in the area of financial planning (Case D, E, F, G, H). Securing adequate and predictable funding remains a constraint, limiting the ability to plan investments and maintenance activities in a systemic and sustainable manner. Project implementation also emerges as a critical area. Several local governments report limitations in internal technical and administrative capacity to effectively execute WASH-related projects (Case A, B, D, E, F, G, H). Such capacity constraints contribute to delays, reduced efficiency in project delivery, and greater reliance on external actors, potentially affecting institutional learning and the long-term sustainability of investments (Chaponda *et al.*, 2020; OECD, 2020).

Third, these patterns point to a strategy implementation gap across the analysed local governments. While strategic and financial planning documents frequently acknowledge future WASH development and maintenance needs, their translation into operational practice remains uneven. Many municipalities recognize increasing investment requirements associated with ageing infrastructure portfolios (Cases A, B, C, E, G, H), as well as the growing importance of technical innovation (Cases A, B, E, G, H). However, constraints in both financial (Case D, E, F, G, H) and human resources (Case A, B, D, E, F, G, H) appear to hinder their ability to implement these strategic priorities as intended. Consequently, several

municipalities continue to rely on reactive approaches to asset management and report to have increasingly ageing infrastructure (Case A, B, C) and substantial infrastructure backlog (Case D, E, F, G). In practice, this often translates into reactive interventions, rather than preventive or lifecycle-based maintenance strategies. Strategy implementation gaps are widely discussed in strategic management literature (e.g. George, 2021) and have also been particularly acknowledged in studies on WASH infrastructure management (e.g. Mazele and Amoah, 2022; Dithebe *et al*., 2019; Ruiters and Matji, 2016). The findings therefore suggest that strengthening the link between strategic planning and execution remains an important area for improvement.

Fourth, this study finds that the design and reliability of funding systems influence the ability of the analysed local governments to implement WASH strategies and adopt proactive infrastructure management practices, particularly for larger-scale infrastructure investments. In the Swiss municipalities analysed (Case A, B, C), WASH maintenance and investment are financed entirely through fee-based models operated via special-purpose vehicles. When applied as intended, these financial vehicles facilitate that the revenues are channelled into special-purpose funds reserved exclusively for WASH infrastructure expenditure, separating WASH spending from general tax revenues and avoiding competition with other policy areas during budget negotiations. Fee-based funding mechanisms are also present in the Indonesian and South African cases. However, in these contexts, user fees are insufficient to meet maintenance and investment requirements. As a result, municipalities depend on supplementary transfers or grants (Cases E, F, G, H), which typically originate from higher tiers of government. These transfers are often unpredictable and contingent on prevailing political priorities, reducing the reliability of funding over time. The challenges associated with insufficient or unreliable funding are consistent with prior research (e.g. Bose *et al*., 2024; Chandratreya, 2023; Jiang, 2023; Ruiters and Matji, 2016), although the comparative perspective adopted in this study highlights how differences in funding reliability shape the capacity of local governments across diverse governance contexts.

Fifth, the analysis suggests that differences in WASH management practices are more pronounced across functional pillars of WASH asset management than across the analysed local governments. Although we acknowledge the importance of financial resources and well-developed funding systems, they do not seem to fully explain observed differences in WASH management practices. Certain challenges, such as ageing infrastructure and reliance on outsourcing, occur across countries, institutional contexts and available financial resources. This suggests that financial resources, although necessary, are not sufficient on their own to ensure effective WASH infrastructure management. Additional organizational and institutional factors, including governance arrangements and stakeholder engagement, also shape WASH management practices. For example, practices in South Africa and Indonesia suggest a strong commitment to public and stakeholder participation (Cases D, E, G, H), which is less evident in Swiss cities (Cases A, B, C). Interestingly, these results challenge conventional expectations in the literature, which suggest that contextual variation between local governments (e.g. the level of available financial resources) would lead to more heterogeneous national WASH management practices (Dahal *et al*., 2025; Cord *et al*., 2022).

Consequently, the analysis of WASH infrastructure management across the analysed local governments highlights the complexity of achieving proactive service delivery. This study assumes that navigating this complexity rests and depends on the interaction of multiple, interrelated capacities, including strategic planning, financial sustainability, operational implementation, and asset monitoring. Acknowledging this assumption, this study implies that improving WASH infrastructure management practices cannot be achieved through a single focus on individual pillars of the conceptual framework. Instead, WASH infrastructure management practices require a holistic and integrated approach. Furthermore, we also need to acknowledge macro-level developments (e.g. political,

economic, social, technological, environmental and legal spheres). For example, the economic conditions (e.g. access to finance) seem to be unevenly developed in different contexts. Hence, developing financing mechanisms at the intersection of public, concessional, and commercial finance, coupled with stronger public–private and cross-institutional collaboration, appears essential to enable long-term investment in backbone WASH infrastructure (Pories *et al*., 2019; Mazzucato and Kühn von Burgsdorff, 2025). At the same time, strengthening legal and governance frameworks, including clearly defined roles and responsibilities of authorities and service providers, provides a foundation for coordinated action (Hosseinpourtehrani, 2021; Hanis *et al*., 2011; Mazele and Amoah, 2022).

6.1 Contribution to theory and practice

This paper makes several contributions to theory and practice. First, it proposes a new conceptual framework that enables a systematic comparison of infrastructure management practices. Second, it addresses a notable gap in the academic literature by providing comparative empirical evidence on WASH infrastructure management across local governments. Third, the study offers comparative insights into public WASH infrastructure management from municipalities operating under contrasting socio-economic conditions, geographic characteristics, and governance arrangements. Fourth, the paper identifies both common (e.g. strategy implementation gap, limited financial and human resources) and context-specific challenges (e.g. lack of technical advancements, carbon-neutral infrastructure development) in WASH infrastructure management practices and discusses potential avenues for policymakers to address these challenges and support future pathways for improvement.

7. Limitations and future research

Despite its contributions, this study has limitations. First, the selection of municipalities was not random but based on existing networks and connections. This introduces the risk of selection bias. Future research could address this by applying the conceptual framework developed in this study to a randomly selected sample of municipalities. Second, the comparability of the municipalities is constrained by differences in context, population size, budget, and infrastructure needs. For instance, Swiss cities are smaller compared to large metropolitan cities in Indonesia and South Africa. Future studies might therefore focus on more contextually and structurally comparable municipalities. A third limitation concerns the institutional fragmentation and variation in governance arrangements. Political, administrative, and financial responsibilities differ across actors and government levels. Although interviewees were carefully selected to capture diverse perspectives, there remains the risk that certain practices or challenges were omitted due to the subjective and potentially limited viewpoints of respondents. Future research could address this by conducting in-depth single case studies to capture the full range of functions and perspectives involved in WASH infrastructure management. Lastly, this study is subject to the general limitations of qualitative research designs. While the findings provide valuable empirical insights into WASH-related practices and challenges, the evidence should be viewed as anecdotal rather than representative.

Annex

Table A1. Codebook

Codebook	Frequency
Asset planning and budgeting (D)	*108*
Multi-year investment programs (D)	27
Investment appraisal (D)	14
Public participation (D)	25
Maintenance planning and engineering (D)	39
Costs (I)	3
Financial Planning (D)	*50*
Integrated planning and budgeting (D)	13
Funding Sources (D)	8
Funding gaps (D)	19
Emergency budget (I)	1
Budget adaptations (I)	6
Commitment control (I)	3
Project implementation (D)	*38*
Procurement process (D)	9
Outsourcing (D)	22
Internal Capacities (D)	7
Asset reporting (D)	*48*
Asset register (D)	9
Depreciation (D)	13
Update and reconciliation Asset Information (D)	26
Governance Arrangements (D)	*35*
Intermunicipal Cooperations (I)	2
Intergovernmental Coordination (I)	10
Responsibilities (D)	23
Challenges (I)	*33*
Sustainability (I)	6
Investments (I)	3
Water Quality (I)	2
Maintenance technologies (I)	3
Old Infrastructure (I)	6
Lack of Information (I)	2
Capacity (I)	4
Overspending (I)	7
Total Codes	*312*

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