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Water Infrastructure and Facilities Management in Africa: A Critical Review of Infrastructure Decay and Facility Maintenance in Sub-Saharan Africa

Kumo Hassan Ali[a*], Mat Naim Abdullah @ Asmoni[a], Mohd Saidin Misnan[b] & S.G. Dalibi[c]

[a]*Department of Real Estate, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*

[b]*Department of Quantity Surveying, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*

[c]*Department of Quantity Surveying, Faculty of Environment Sciences, Gombe State University (GSU), Gombe, Nigeria*

**Corresponding author: ali.kumo@graduate.utm.my / halikumo@gmail.com*

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ABSTRACT

Water infrastructure decay and facility maintenance failures represent a silent crisis across Africa, yet systematic analysis of why infrastructure deteriorates and why maintenance systems persistently fail remains limited. This study critically reviews water infrastructure decay and facility maintenance across five African countries Nigeria, Ethiopia, Democratic Republic of Congo, South Africa, and Morocco using desk research methodology that synthesizes academic literature, institutional reports, utility audits, and NGO evaluations. The findings reveal that maintenance failure is systemic, not accidental, driven by predictable patterns of underfunding (maintenance budgets at 2-12% of capital value versus 15-20% needed), institutional fragmentation, corruption, spare parts supply chain failures, and perverse political incentives favoring new construction over asset preservation. Consequences include intermittent water supply, waterborne diseases (cholera, typhoid, diarrheal disease causing ~200,000 annual child deaths across Sub-Saharan countries), high lifecycle costs (replacement costing 3-5 times maintenance), and disproportionate burdens on poor and rural communities. The study contributes a root cause analysis framework distinguishing immediate, underlying, and systemic causes, a comparative assessment of five diverse nations, and actionable recommendations for governments (dedicated maintenance budgets, asset management systems), donors (shift funding from new construction to maintenance), utilities (preventative maintenance, staff training), and communities (strengthened maintenance committees, local technician training). Addressing infrastructure decay requires simultaneous intervention at all three causal levels not just repairing broken pumps but reforming budgets, strengthening institutions, and changing donor and political incentives.

Keywords: Water infrastructure; facility maintenance; infrastructure decay; Sub-Saharan Africa; management; root cause analysis

INTRODUCTION

BACKGROUND TO THE STUDY

Water infrastructure serves as the foundational pillar for water security across Sub-Saharan Africa. According to Igbokwe et al. (2022), reliable water supply systems including treatment plants, distribution networks, and storage facilities directly determine whether populations can access safe drinking water for domestic use, sanitation, and economic activities. Lehner et al. (2023) emphasize that without functional infrastructure, even water-abundant regions cannot translate resources into actual service delivery. As African Development Bank (2018) documented, nearly 400 million people in Sub-Saharan Africa lack access to clean water primarily due to infrastructure deficits rather than absolute water scarcity.

Despite substantial investments in water infrastructure over past decades, a troubling pattern has emerged across the continent. Nwachukwu et al. (2017) observed that many water systems constructed with donor and government funding deteriorate rapidly within five to ten years of completion. Akinmoladun et al. (2019) noted that in Nigeria, water treatment plants built in the 1980s and 1990s now operate at less than 30% of designed capacity due to neglect and deferred maintenance. Bassey et al. (2020) documented similar patterns across other Sub-Saharan nations, where initial capital investments are rarely followed by adequate operational budgets.

This pattern has been characterized as the "build-neglect-rebuild" cycle, a phenomenon that undermines long-term water security. Ekpo et al. (2021) described how governments and development partners repeatedly prioritize new construction over maintenance of existing assets, creating a cycle of waste and inefficiency. Ogunbode et al. (2021) estimated that replacing failed infrastructure costs three to five times more than maintaining it properly from the outset. Moriarty et al. (2019) argued that this cycle persists because maintenance receives political and financial attention only after major failures occur, rather than as a routine operational necessity. Breaking this cycle requires systematic understanding of why decay occurs and how maintenance systems fail.

The widespread decay of water infrastructure represents a silent crisis across Sub-Saharan Africa. Tantoh et al. (2021) reported that thousands of boreholes, handpumps, piped networks, and treatment facilities have fallen into disrepair, leaving communities without access to the very services these assets were designed to provide. Nwachukwu et al. (2020) documented that in Nigerian cities such as Lagos and Kano, aging distribution networks lose 30-50% of treated water through leaks and breaks before reaching consumers. Oluduro et al. (2020) similarly found that deteriorating storage reservoirs and pumping stations in South Africa contribute to intermittent supply and water quality violations, demonstrating that decay affects all infrastructure types across the service chain.

The maintenance gap is starkly evident in functionality statistics across the region. According to Igbokwe et al. (2022), between 30% and 50% of rural water infrastructure in Sub-Saharan Africa is non-functional at any given time, with handpumps and boreholes experiencing particularly high failure rates. Akinmoladun et al. (2019) estimated that in Ethiopia, nearly 40% of rural water points constructed within the last decade are no longer operational due to maintenance failures. Gleick (2018) noted that this level of non-functionality translates into millions of people reverting to unsafe water sources, perpetuating waterborne diseases and undermining progress toward Sustainable Development Goal 6. Lehner et al. (2023) concluded that the maintenance gap is not a technical problem alone but a systemic failure spanning financial, institutional, and governance domains.

Despite the severity of infrastructure decay, limited systematic analysis exists on why decay occurs and persists across Sub-Saharan Africa. Mubiala et al. (2022) observed that most water sector research focuses on governance frameworks, climate adaptation, or technological innovation, leaving infrastructure maintenance as an understudied dimension. Olawale et al. (2021) noted that even when studies document non-functionality rates, they rarely analyze the root causes of maintenance failure or compare patterns across multiple countries. Ekpenyong et al. (2020) argued that without understanding the specific mechanisms of decay whether technical, financial, institutional, or a combination policymakers cannot design effective interventions. Houghton et al. (2021) called for critical, multi-country reviews that move beyond documenting failure to explaining its persistence and recommending actionable solutions.

RESEARCH PURPOSE

This paper aims to critically review the state of water infrastructure decay and facility maintenance across Sub-Saharan Africa, with a particular focus on understanding why infrastructure deteriorates and why maintenance systems persistently fail. According to Akinmoladun et al. (2020), the water sector lacks systematic, multi-country analyses that specifically examine infrastructure decay as a distinct phenomenon separate from broader water governance debates. Lehner et al. (2023) argued that most existing research emphasizes new infrastructure development rather than the lifecycle management of existing assets, leaving critical gaps in understanding maintenance failures. As Igbokwe et al. (2022) asserted, without a focused review of decay patterns and maintenance deficiencies, policymakers cannot design evidence-based interventions to reverse the "build-neglect-rebuild" cycle that plagues the region.

SCOPE AND DELIMITATION

This review is geographically delimited to Sub-Saharan Africa, with focused analysis on five case study countries Nigeria, Ethiopia, the Democratic Republic of Congo, Morocco and South Africa selected to represent West, East, Central, North and Southern Africa respectively. Nwachukwu et al. (2020) justified this geographic scope by noting that Sub-Saharan Africa faces distinct infrastructure challenges compared to North Africa, including lower investment levels, weaker institutional capacity, and different climatic conditions. The infrastructure focus is restricted to drinking water supply systems, specifically treatment plants, distribution networks, and storage facilities, excluding sanitation and irrigation infrastructure.

Ekpo et al. (2021) emphasized that maintenance is examined across four typologies operational, routine, preventative, and corrective to capture the full spectrum of maintenance activities. North African countries (Egypt and Morocco) are explicitly excluded from this review, as Bassey et al. (2020) recommended that their distinct hydrological and economic contexts warrant separate analysis in a future comparative study.

SIGNIFICANCE OF THE STUDY

This study fills a critical gap in the literature by providing the first dedicated, multi-country critical review focused specifically on water infrastructure decay and maintenance failures in Sub-Saharan Africa. Ogunbode et al. (2021) observed that while infrastructure decay is widely acknowledged as a problem, few studies systematically analyze its causes, patterns, and persistence across multiple national contexts. The review provides evidence-based support for maintenance-first policy approaches, challenging the dominant paradigm that prioritizes new construction over asset management. As Moriarty et al. (2019) argued, shifting policy attention toward maintenance can yield higher returns on infrastructure investments and more sustainable service delivery. Finally, this study directly supports the achievement of Sustainable Development Goal 6, which aims to ensure availability and sustainable management of water and sanitation for all. United Nations (2020) noted that without functional infrastructure that is properly maintained, progress toward SDG 6 targets will remain elusive regardless of how much new infrastructure is constructed.

LITERATURE REVIEW

CONCEPTUAL FRAMEWORK

INFRASTRUCTURE LIFECYCLE THEORY

Infrastructure lifecycle theory provides the foundational lens for understanding why water assets decay and how maintenance interventions can extend service life. According to Cech (2018), every infrastructure asset progresses through distinct stages: planning, design, construction, operation, maintenance, rehabilitation, and eventual decommissioning or replacement. Gleick (2018) emphasized that the operational and maintenance phases collectively account for 70-80% of total lifecycle costs, yet receive the least attention in infrastructure planning and budgeting across developing contexts. As Moriarty et al. (2019) argued, ignoring the full lifecycle leads to the "build-neglect-rebuild" cycle, where assets fail prematurely not because of poor construction but because of inadequate post-commissioning care. This theory directly informs the present review by shifting analytical focus from initial capital investment to the long-term management of existing assets.

ASSET MANAGEMENT PRINCIPLES (ISO 55000)

Asset management principles, codified in the ISO 55000 series, offer a systematic framework for optimizing infrastructure performance throughout its lifecycle. According to Li et al. (2022), effective asset management requires organizations to maintain comprehensive asset registers, conduct condition assessments, forecast future performance, and allocate resources based on risk and criticality. Scanlon et al. (2023) noted that ISO 55000 principles have been successfully applied in water utilities across developed countries, resulting in extended asset life and reduced lifecycle costs. However, Lehner et al. (2023) observed that few Sub-Saharan African water utilities have adopted formal asset management systems, instead operating with incomplete asset data and reactive maintenance approaches. This framework is applied in this review as a normative benchmark against which current maintenance practices across the four case study countries are assessed.

MAINTENANCE TYPOLOGIES

Maintenance activities are conventionally classified into four distinct typologies, each with different purposes, costs, and operational implications. According to Ficklin et al. (2022), routine maintenance involves daily or weekly tasks such as cleaning, lubrication, and inspection, while preventative maintenance refers to scheduled interventions like pump overhauls or filter replacements performed before failure occurs. Makanda et al. (2022) distinguished corrective maintenance as repairs carried out after equipment has failed, and predictive maintenance as condition-based interventions triggered by monitoring data indicating impending failure. As Bassey et al. (2020) documented, water utilities across Sub-Saharan Africa rely predominantly on corrective maintenance, addressing failures only after service disruption occurs, while neglecting routine and preventative approaches that are more cost-effective and less disruptive. This review adopts this typology to characterize current maintenance practices and diagnose where breakdowns occur.

INFRASTRUCTURE DECAY MODELS

Infrastructure decay models, particularly deterioration curves and failure pattern analysis, provide quantitative tools for predicting asset performance over time. According to Lehner et al. (2023), deterioration curves typically follow a characteristic "bathtub" shape, with high initial failure rates (burn-in period), followed by a long period of low, constant failures (useful life), and finally increasing failures as assets approach end-of-life (wear-out period). Ogunbode et al. (2021) applied these models to water pipelines in Nigerian cities, finding that many assets are operating in the wear-out phase without adequate rehabilitation. Ekpo et al. (2021) noted that failure patterns are exacerbated in Sub-Saharan Africa by environmental stressors (heat, flooding) and operational neglect, accelerating deterioration beyond standard model predictions. Understanding these decay models is essential for this review because they explain why infrastructure fails earlier and more catastrophically when maintenance is deferred.

WATER INFRASTRUCTURE IN SUB-SAHARAN AFRICA: AN OVERVIEW

TYPES OF INFRASTRUCTURE

Water infrastructure across Sub-Saharan Africa encompasses a diverse range of asset types, from simple community-managed handpumps to complex urban treatment plants. According to Nwachukwu et al. (2017), boreholes equipped with handpumps represent the most common improved water source for rural communities, serving approximately 30-40% of rural populations across Nigeria, Ethiopia, and DRC. Akinmoladun et al. (2019) noted that piped distribution networks are concentrated in urban centers, though coverage remains incomplete even in major cities like Lagos and Kinshasa, where many residents rely on informal vendors or unsafe sources. Treatment plants and storage reservoirs are the least common and most capital-intensive assets, with Tshimanga et al. (2022) documenting that DRC has fewer than ten operational large-scale treatment facilities serving a population exceeding 100 million, while South Africa maintains a relatively robust network of dams and treatment works from the apartheid era (Oluduro et al. 2020). These are shown in the table below.

TABLE 1. Types of Water Infrastructure Across Sub-Saharan Africa

Infrastructure Type	Primary Location	Typical Users	Common Failure Modes	Maintenance Complexity
Boreholes	Rural	Small communities (100-500 people)	Pump failure, falling water table, corrosion	Low to moderate
Handpumps	Rural	Households, community kiosks	Seal wear, broken handles, cylinder failure	Low
Piped networks	Urban/peri-urban	Household connections, public standpipes	Leakage, pipe bursts, pressure loss	High
Treatment plants	Urban	Entire cities or districts	Filter clogging, chemical dosing failures, pump breakdown	Very high
Storage reservoirs	Urban/rural	Distribution system storage	Sedimentation, structural cracks, valve failures	Moderate to high

Source: Authors' synthesis based on Akinmoladun et al. (2019), Nwachukwu et al. (2017), and Tshimanga et al. (2022)

HISTORICAL DEVELOPMENT AND INVESTMENT PATTERNS

The historical development of water infrastructure in Sub-Saharan Africa reflects shifting priorities among colonial administrations, post-independence governments, and international donors. According to Igbokwe et al. (2022), colonial powers built limited water systems primarily serving European settlements and administrative centers, leaving indigenous populations with minimal access a pattern evident in DRC's Kinshasa, where colonial-era infrastructure still serves a small fraction of the city. Post-independence decades saw expanded investment, but Bassey et al. (2020) noted that much of this infrastructure was donor-funded with inadequate provisions for long-term operation and maintenance. Since the 1990s, development assistance has shifted toward community-managed rural water points and public-private partnerships for urban systems, yet Gleick (2018) observed that investment remains heavily skewed toward new construction rather than rehabilitation or maintenance of existing assets. These are shown in the table below.

TABLE 2. Historical Investment Patterns in Water Infrastructure by Era

Era	Dominant Infrastructure Type	Primary Funder	Maintenance Provisions	Legacy Today
Colonial (pre-1960)	Piped networks in administrative centers	Colonial governments	Colonial budgets; minimal local capacity	Aging assets; limited coverage
Post-independence (1960s-1980s)	Urban treatment plants, rural boreholes	National governments + World Bank	Weak; often none	Many systems collapsed or operating below capacity
Structural adjustment (1980s-1990s)	Rural handpumps, community schemes	Donors (IMF, World Bank)	Community-based (unfunded mandates)	High non-functionality rates
MDG/SDG era (2000s-present)	Mixed: urban piped, rural boreholes, some treatment	Donors, PPPs, national budgets	Increasing attention but still underfunded	Mixed performance; ongoing decay

Source: Authors' synthesis based on Igbokwe et al. (2022), Bassey et al. (2020), and Gleick (2018)

CURRENT COVERAGE STATISTICS

Current water coverage statistics reveal stark disparities between urban and rural areas, and among the four focus countries. According to African Development Bank (2018), access to at least basic drinking water services ranges from less than 50% in DRC and Ethiopia to approximately 85-90% in South Africa and parts of Nigeria. Lehner et al. (2023) reported that rural coverage lags significantly behind urban areas across all four countries, with rural populations in Ethiopia and DRC experiencing less than 40% access to improved water sources. Nwachukwu et al. (2020) noted that even where coverage statistics appear adequate, service continuity is often poor Nigerian residents with nominal "access" frequently receive water only a few hours per day or multiple days per week. These coverage statistics, while useful for benchmarking, conceal the underlying infrastructure decay that compromises service quality and reliability. These are shown in the table below.

TABLE 3. Current Water Coverage Statistics by Country

Country	Urban Access (%)	Rural Access (%)	National Access (%)	Service Continuity (hours/day typical)	Primary Infrastructure Type
Nigeria	70-80%	50-60%	60-70%	4-12 (intermittent)	Boreholes, piped networks (urban)
Ethiopia	60-70%	30-40%	40-50%	2-8	Handpumps, boreholes (rural); limited piped (urban)
DRC	50-60%	20-30%	30-40%	Highly variable	Colonial-era piped (Kinshasa); boreholes, surface water (rural)
Morocco	95-98%	85-90%	90-95%	20-24 (major cities); 8-16 (rural/small towns)	Large dams (140+), ONEE piped networks, desalination plants, irrigation systems
South Africa	85-95%	70-80%	85-90%	20-24 (major cities); lower in rural	Dams, treatment plants, extensive piped networks

Source: Authors' synthesis based on African Development Bank (2018), Lehner et al. (2023), and Nwachukwu et al. (2020)

THE MAINTENANCE DEFICIT IN SUB-SAHARAN AFRICA

QUANTIFYING THE GAP (BUDGET VS. NEED)

The maintenance funding gap across Sub-Saharan Africa is substantial, with available budgets representing only a fraction of estimated requirements. According to Moriarty et al. (2019), water sector guidelines recommend allocating 15-20% of initial capital costs annually for routine and preventative maintenance, yet actual budgets across the four focus countries range from 2-10% of capital spending. Ekpo et al. (2021) calculated that Nigeria's water utilities spend approximately 5-8% of their operating budgets on maintenance, compared to an estimated 20-25% needed to prevent asset deterioration. In DRC, Kapembo et al. (2022) noted that maintenance budgets are virtually non-existent outside of donor-funded projects, with most utilities operating on crisis-driven repairs funded by emergency allocations. This persistent underfunding, Olawale et al. (2021) argued, reflects not only resource constraints but also systematic de-prioritization of maintenance in budget formulation and political discourse. These are shown in the table below.

TABLE 4. Maintenance Budget Gap Analysis by Country

Country	Estimated Maintenance Need (% of capital cost/ year)	Actual Maintenance Budget (% of capital cost/year)	Gap (% points)	Consequences of Gap
Nigeria	20-25%	5-8%	15-17%	Accelerated pipe corrosion; pump failures; treatment plant downtime
Ethiopia	15-20%	3-6%	12-14%	Rural handpump failures; borehole sedimentation
DRC	15-20%	<2%	13-18%	Complete system collapse in many areas; donor dependency
Morocco	12-18%	6-10%	6-8%	Aging secondary network leaks; rural system underperformance; desalination plant maintenance backlogs
South Africa	15-20%	8-12%	7-8%	Aging infrastructure failures; "Day Zero" crisis

Source: Authors' synthesis based on Moriarty et al. (2019), Ekpo et al. (2021), Kapembo et al. (2022), and Olawale et al. (2021)

FUNCTIONAL VS. NON-FUNCTIONAL INFRASTRUCTURE RATES

Functionality rates the proportion of installed infrastructure that is operational at a given timereveal the true extent of the maintenance crisis. According to Igbokwe et al. (2022), between 30% and 50% of rural water points across Sub-Saharan Africa are non-functional at any given time, with handpumps experiencing the highest failure rates. Akinmoladun et al. (2019) reported that in Ethiopia's rural regions, approximately 40% of boreholes and handpumps constructed within the last decade are no longer operational, with the primary causes being broken pumps, lack of spare parts, and absent maintenance systems. In South Africa, Oluduro et al. (2020) noted that while urban functionality rates remain relatively high (85-90%), rural areas and small towns experience significantly lower rates, with some municipalities reporting 30-40% of water treatment works operating below design capacity. These functionality statistics, Tantoh et al. (2021) argued, represent not merely technical failures but systemic governance failures. These are shown in the table below.

TABLE 5. Functional vs. Non-Functional Infrastructure Rates by Type

Infrastructure Type	Typical Functionality Rate (Urban)	Typical Functionality Rate (Rural)	Primary Failure Cause	Time to Failure (median)
Boreholes with handpumps	N/A	50-70%	Pump failure; lack of spare parts	3-7 years
Handpumps (standalone)	N/A	40-60%	Seal wear; broken handles; cylinder failure	2-5 years
Piped networks	70-85% (intermittent)	30-50%	Leakage; pressure loss; pipe bursts	Ongoing
Treatment plants	60-75%	N/A	Chemical dosing failures; pump breakdowns	5-15 years
Storage reservoirs	75-85%	40-60%	Sedimentation; valve failures	10-20 years

Source: Authors' synthesis based on Igbokwe et al. (2022), Akinmoladun et al. (2019), Oluduro et al. (2020), and Tantoh et al. (2021)

SPARE PARTS SUPPLY CHAIN FAILURES

The breakdown of spare parts supply chains represents a critical yet underrecognized driver of infrastructure decay across Sub-Saharan Africa. According to Bassey et al. (2020), even when maintenance budgets exist and technicians are available, the absence of appropriate spare parts prevents timely repairs, transforming minor issues into major failures. Nwachukwu et al. (2017) documented that in Nigeria, spare parts for imported pumps and treatment equipment often require weeks or months to procure, as local suppliers are scarce and international procurement processes are cumbersome. In DRC, Kayembe et al. (2018) observed that the combination of poor roads, conflict zones, and weak logistics infrastructure means spare parts rarely reach rural communities, leaving broken handpumps unrepaired for years. Ogunbode et al. (2021) noted that supply chain failures are exacerbated by reliance on imported components, lack of local manufacturing capacity, and absence of inventory management systems at utility and district levels. Addressing this supply chain gap, Lehner et al. (2023) argued, is as essential as increasing maintenance budgets. These are shown in the table below.

TABLE 6. Spare Parts Supply Chain Challenges by Country

Country	Lead Time for Common Spare Parts	Local Availability	Primary Supply Chain Barrier	Consequences
Nigeria	2-8 weeks (imported); 1-2 weeks (local)	Moderate (urban); Very low (rural)	Import dependency; customs delays	Extended downtime; minor failures escalate
Ethiopia	4-12 weeks	Low	Poor distribution networks; foreign exchange shortages	High non-functionality rates
DRC	3-6 months (rural); 2-4 weeks (Kinshasa)	Very low	Conflict zones; poor roads; no local manufacturing	Near-permanent disrepair in rural areas
Morocco	1-3 weeks (urban); 2-5 weeks (rural)	Moderate (urban); Low-Moderate (rural)	Import dependency for specialized parts; rural distribution gaps	Extended downtime in rural areas; secondary network leaks persist
South Africa	1-4 weeks	Moderate to high (urban); Low (rural)	Municipal procurement inefficiencies; funding delays	Service interruptions; water quality violations

Source: Authors' synthesis based on Ait Kadi & Ziyad (2018), and Alaoui (2013), Bassey et al. (2020), Nwachukwu et al. (2017), Kayembe et al. (2018), Ogunbode et al. (2021), and Lehner et al. (2023)

CAUSES OF INFRASTRUCTURE DECAY

TECHNICAL CAUSES

Technical factors represent the most immediate causes of water infrastructure decay, encompassing aging assets, material corrosion, poor construction quality, and systematic lack of spare parts. According to Nwachukwu et al. (2017), much of Sub-Saharan Africa's water infrastructure, particularly in Nigeria and DRC, has exceeded its designed lifespan by decades, with pipes and pumps operating 30-50 years beyond intended retirement dates. Akinmoladun et al. (2019) documented that corrosion of metal pipes and pump components is accelerated by poor water quality, high temperatures, and lack of protective coatings, leading to progressive wall thinning, leaks, and catastrophic failures.

Bassey et al. (2020) observed that poor construction quality including inadequate compaction around pipes, substandard materials, and shortcuts during installation creates inherent weaknesses that manifest as premature failures within the first few years of operation. The absence of spare parts, as Kayembe et al. (2018) noted in DRC, transforms minor, repairable issues (worn seals, broken handles) into permanent failures, as technicians cannot source replacements locally and international procurement takes months. These are shown in the table below.

TABLE 7. Technical Causes of Infrastructure Decay by Infrastructure Type

Technical Cause	Affected Infrastructure	Mechanism of Decay	Mitigation Requirement	Prevalence Across Countries
Aging beyond design life	Pipes, pumps, treatment plants	Material fatigue; reduced structural integrity	Replacement or major rehabilitation	High (Nigeria, DRC, SA)
Corrosion	Metal pipes, pump components, storage tanks	Wall thinning; pitting; eventual perforation	Protective coatings; cathodic protection; material selection	Very high (all countries)
Poor construction quality	Piped networks, boreholes, reservoirs	Soil infiltration; pipe misalignment; weak joints	Quality assurance during construction; proper supervision	Moderate-High (Nigeria, Ethiopia, DRC)
Lack of spare parts	Handpumps, boreholes, pump stations	Extended downtime; component substitution with incompatible parts	Local supply chains; inventory management	Severe (DRC, rural Ethiopia, rural Nigeria)
Sedimentation	Storage reservoirs, intake structures	Reduced storage capacity; pump damage	Sediment removal; watershed management	Moderate (Ethiopia, SA)

Source: Authors' synthesis based on Ait Kadi & Ziyad (2018), and Alaoui (2013), Nwachukwu et al. (2017), Akinmoladun et al. (2019), Bassey et al. (2020), and Kayembe et al. (2018)

FINANCIAL CAUSES

Financial constraints are primary drivers of infrastructure decay, manifesting as chronically insufficient maintenance budgets and systematic donor bias toward new construction over asset management. According to Moriarty et al. (2019), water utilities across Sub-Saharan Africa allocate only 2-10% of their operating budgets to maintenance, compared to the 15-20% recommended for asset preservation, creating a predictable cycle of accelerated deterioration. Ekpo et al. (2021) documented that in Nigeria, maintenance budgets are often the first line item cut during fiscal crises, with funds diverted to politically visible new projects rather than unglamorous repairs.

The donor funding bias toward new construction, Igbokwe et al. (2022) observed, is particularly problematic: international development partners prefer financing new boreholes, treatment plants, or piped networks because these yield measurable outputs and photographic evidence of progress, while maintenance funding produces no visible "inauguration" opportunities. Olawale et al. (2021) noted that this bias extends to national governments as well, where politicians prioritize ribbon-cutting for new facilities over sustaining existing assets that do not generate political credit. These are shown in the table below.

TABLE 8. Financial Causes of Infrastructure Decay by Dimension

Financial Cause	Mechanism	Evidence Across Countries	Magnitude of Impact	Policy Solution
Insufficient maintenance budgets	Underfunded routine and preventative maintenance	Nigeria (5-8% of capital); Ethiopia (3-6%); DRC (<2%); South Africa (8-12%); Morocco (6-10%) vs. need (12-18% for Morocco, 15-20% for others)	High to severe (moderate for Morocco)	Ring-fenced maintenance budgets (min. 15% of capital; 10-12% for Morocco given newer infrastructure)
Budget volatility	Reallocation during fiscal stress	Utility financial reports show maintenance as first cut across all five countries; Morocco less severe due to stronger fiscal discipline	Moderate-High (low-moderate for Morocco)	Multi-year maintenance appropriations
Donor bias toward new construction	80-90% of WASH funding for new assets vs. maintenance	World Bank project portfolio analysis; OECD DAC data; Morocco receives more maintenance-focused loans from AFD, World Bank	High (moderate for Morocco)	Donor maintenance set-asides (20% of project funds)
Political economy of ribbon-cutting	Leaders prefer inaugurations over maintenance	Anecdotal; observable in all five countries; Morocco's King and government prioritize major water projects (dams, desalination) over maintenance	Moderate-High (moderate for Morocco)	Performance-based funding linked to asset condition
Low tariff recovery	Inadequate revenue for operations including maintenance	South Africa (partial cost recovery); Nigeria/DRC/Ethiopia (<30% cost recovery); Morocco (60-70% cost recovery, higher than Sub-Saharan but below European benchmarks)	High (moderate for Morocco)	Graduated tariff reforms with pro-poor protections

Source: Authors' synthesis based on Moriarty et al. (2019), Ekpo et al. (2021), Igbokwe et al. (2022), and Olawale et al. (2021), Ait Kadi & Ziyad (2018), and Alaoui (2013)

INSTITUTIONAL CAUSES

Institutional weaknesses including fragmented oversight, corruption, staff shortages, and lack of technical training systematically undermine maintenance capacity across Sub-Saharan Africa. According to Igbokwe et al. (2022), water management in Nigeria is split across federal, state, and local agencies with overlapping mandates and no clear accountability for maintenance, creating gaps where no agency takes responsibility for decaying assets. Oluduro et al. (2020) documented that corruption manifests in maintenance systems through inflated procurement contracts, diversion of spare parts to private resale, and ghost workers on utility payrolls, diverting resources away from actual repairs.

Staff shortages, Ogunbode et al. (2021) reported, mean that many water utilities operate with 30-50% of authorized positions filled, and those remaining often lack training on modern equipment, leading to improper repairs that accelerate rather than resolve decay. In DRC, Tshimanga et al. (2022) observed that institutional capacity is so weak that even donor-funded maintenance programs fail when external support ends, as local institutions lack the systems, skills, and accountability to continue routine asset management. These are shown in the table below.

TABLE 9. Institutional Causes of Infrastructure Decay by Country

Fragmented oversight	Severe (3+ agency levels)	Moderate (centralized)	Severe (weak central + no local)	Low-moderate (clear mandates but weak coordination)	Low-moderate (clear mandates; coordination challenges between ONEE, ministry, and regional authorities)	No clear maintenance responsibility
Corruption	High (procurement, payroll)	Moderate	Severe (systemic)	Low-moderate (tender irregularities)	Low-moderate (limited; procurement irregularities reported but not systemic)	Diverted resources; poor quality repairs
Staff shortages	30-50% vacancies	20-40% vacancies	50-70% vacancies	15-25% vacancies	10-20% vacancies (urban); 20-30% (rural)	Undermanned maintenance units
Lack of technical training	Widespread	Moderate (rural focus)	Severe	Low-moderate (aging workforce)	Low-moderate (ONEE has training programs; rural capacity gaps remain)	Improper repairs; diagnostic failures
Weak accountability	High	Moderate	Severe	Moderate (improving)	Low-moderate (stronger oversight than Sub-Saharan Africa; but rural accountability gaps)	No consequences for asset neglect

Source: Authors' synthesis based on Igbokwe et al. (2022), Oluduro et al. (2020), Ogunbode et al. (2021), and Tshimanga et al. (2022), Ait Kadi & Ziyad (2018), and Alaoui (2013)

ENVIRONMENTAL CAUSES

Environmental stressors including climate change-induced flooding, droughts, sedimentation, and temperature extremes accelerate infrastructure decay beyond normal deterioration rates. According to Lehner et al. (2023), increased flooding across Sub-Saharan Africa scours pipe foundations, inundates pump stations, and introduces sediment into treatment systems, causing immediate damage and long-term wear acceleration. Bassey et al. (2020) documented that in Nigeria, flood events have become more frequent and severe, washing away unprotected pipe crossings and damaging intake structures designed for historical flow regimes.

Extreme temperatures, Akinmoladun et al. (2019) observed, accelerate corrosion rates and degrade plastic pipes and rubber seals, reducing component lifespans by 30-50% compared to temperate climates. Sedimentation from deforestation and poor land management, particularly in Ethiopia's highlands and DRC's deforested watersheds, fills reservoirs and clogs intake screens, requiring more frequent and costly cleaning that cash-strapped utilities defer, leading to progressive capacity loss (Mubiala et al. 2022). These are shown in the table below.

TABLE 10. Environmental Causes of Infrastructure Decay by Stressor

Environmental Stressor	Affected Countries	Mechanism of Decay	Infrastructure at Risk	Climate Change Projection
Flooding	Nigeria, Ethiopia, DRC, SA	Scouring of pipe foundations; inundation of pump stations; debris damage	Piped networks, pump stations, treatment plants, intake structures	Increased frequency and intensity
Drought	Ethiopia, SA, Nigeria(northern part) and Morocco	Groundwater level decline; reduced dilution of contaminants	Boreholes, handpumps, surface water intakes	More frequent and prolonged
Temperature extremes	All selected countries especially Morocco	Accelerated corrosion; degradation of seals and gaskets; pipe embrittlement	All infrastructure types	Increasing temperature trends
Sedimentation	Ethiopia (highlands), DRC (deforested areas)	Reservoir capacity loss; screen clogging; pump wear	Storage reservoirs, intake screens, pumps	Worsening with land use change
Erosion	Ethiopia, DRC, Nigeria	Undermining of pipe supports; exposure of buried pipes	Piped crossings, buried networks	Increases with extreme rainfall

Source: Authors' synthesis based on Lehner et al. (2023), Bassey et al. (2020), Akinmoladun et al. (2019), and Mubiala et al. (2022), Ait Kadi & Ziyad (2018), and Alaoui (2013)

CONSEQUENCES OF INFRASTRUCTURE DECAY

SERVICE DELIVERY FAILURES

Infrastructure decay directly translates into service delivery failures, manifesting as intermittent water supply, low pressure, and complete service disruptions that undermine the very purpose of water systems. According to Nwachukwu et al. (2020), residents of Lagos, Nigeria, receive piped water for only 4-12 hours per day on average, with some neighborhoods enduring weeks without service as distribution networks leak and pressure drops. Ogunbode et al. (2021) documented that in many Nigerian cities, water pressure is so low that water cannot reach upper floors of buildings, forcing residents to install rooftop storage tanks or purchase water from informal vendors at 10-20 times the utility tariff.

In South Africa, Oluduro et al. (2020) noted that aging infrastructure contributed to the 2018 "Day Zero" crisis in Cape Town, where the city nearly ran out of water entirely a catastrophic service failure that required extreme demand management and emergency interventions. These service delivery failures, Tantoh et al. (2021) argued, represent not merely inconvenience but a fundamental failure of the state to fulfill its public service obligations. These are shown in the table below.

TABLE 11. Service Delivery Failures Resulting from Infrastructure Decay

Service Failure Type	Definition	Prevalence by Country	Primary Infrastructure Cause	Impact Severity
Intermittent supply	Water available <24 hours/day	Nigeria (4-12 hrs); Ethiopia (2-8 hrs); DRC (highly variable); South Africa (20-24 hrs in cities, less in rural); Morocco (20-24 hrs in major cities, 8-16 hrs in rural/small towns)	Leaking networks; pump failures; low reservoir levels	High (moderate for Morocco urban)
Low pressure	Inadequate pressure for building delivery	Widespread in Nigeria, Ethiopia, DRC; isolated in South Africa; moderate in Morocco (older districts, rural areas)	Pipe corrosion; pump deterioration; network design issues	Moderate-High
Complete service disruption	No service for days or weeks	Common in DRC (rural); frequent in Nigeria (peri-urban); periodic in Ethiopia; rare in South Africa (except small towns); rare in Morocco (isolated rural events)	Pump failure; pipe bursts; lack of spare parts	Severe (low for Morocco)
Water quality failures	Treated water not meeting standards	Documented in South Africa (some municipalities); common in Nigeria, Ethiopia, DRC where treatment fails; rare in Morocco (ONEE maintains standards in urban areas; rural variability)	Treatment plant breakdowns; distribution network contamination	High (low-moderate for Morocco urban)
Seasonal service loss	Service only during wet season	Common in Ethiopia (dry season failures); present in Nigeria (north); present in Morocco (rural mountain communities, dry season reduction)	Groundwater decline; reservoir depletion; drought	Moderate-High

Source: Authors' synthesis based on Nwachukwu et al. (2020), Ogunbode et al. (2021), Oluduro et al. (2020), Tantoh et al. (2021), Olufemi et al. (2020), Ait Kadi & Ziyad (2018), and Alaoui (2013)

PUBLIC HEALTH IMPACTS

The public health consequences of infrastructure decay are severe and disproportionately affect vulnerable populations, manifesting as increased incidence of waterborne diseases and associated mortality. According to Akinmoladun et al. (2019), when water systems fail, households resort to alternative sources such as unprotected wells, rivers, and vendor-supplied water, which frequently contain fecal contamination and pathogens. Oluduro et al. (2020) documented that Nigeria experiences recurrent cholera outbreaks with thousands of cases and hundreds of deaths annually directly linked to infrastructure failures that force reliance on unsafe sources.

In DRC, Kayembe et al. (2018) found high levels of fecal contamination in drinking water sources during infrastructure outages, contributing to endemic diarrheal disease that remains a leading cause of child mortality. Tantoh et al. (2021) noted that the health burden falls most heavily on children under five, the elderly, and immunocompromised individuals, with diarrheal diseases killing approximately 500,000 children annually in Sub-Saharan Africa deaths that are largely preventable with reliable, well-maintained water infrastructure. These are shown in the table below.

TABLE 12. Public Health Impacts of Infrastructure Decay by Country

Health Outcome	Nigeria	Ethiopia	DRC	South Africa	Mechanism Linking Decay to Health
Cholera outbreaks	Recurrent (annual, thousands of cases)	Sporadic	Endemic in conflict zones	Rare (last major 2008)	Households shift to contaminated surface water during service interruptions
Typhoid fever	Endemic, high burden	Endemic	Endemic, underreported	Low (urban); higher in rural	Inadequate treatment due to plant failures; recontamination in leaking pipes
Diarrheal disease (under-5 mortality)	Very high (~90,000 annual deaths)	High (~70,000)	Very high (~40,000)	Moderate (~1,500)	Cumulative effect of intermittent supply, low pressure, and treatment failures
Chemical contamination	Localized (industrial areas)	Low	Mining areas (heavy metals)	Localized (acid mine drainage)	Treatment plant failures allow contaminant breakthrough
Neglected tropical diseases (trachoma, guinea worm)	Present	High prevalence (trachoma)	Present	Low	Lack of adequate water for hygiene

Source: Authors' synthesis based on Akinmoladun et al. (2019), Oluduro et al. (2020), Kayembe et al. (2018), and Tantoh et al. (2021)

ECONOMIC COSTS

The economic costs of infrastructure decay are substantial and multidimensional, encompassing direct rehabilitation expenses, productivity losses from service interruptions, and broader economic impacts. According to Moriarty et al. (2019), replacing failed infrastructure costs three to five times more than maintaining it properly over its designed lifespan, yet underfunding maintenance ensures that costly replacements are inevitable. Ekpo et al. (2021) estimated that Nigeria loses approximately $2-3 billion annually to water infrastructure decay - a combination of rehabilitation costs, lost water through leaks (30-50% of treated water), and the economic value of time spent collecting water from alternative sources. In South Africa, Oluduro et al. (2020) noted that the 2018 Cape Town "Day Zero" crisis cost the regional economy an estimated $300-500 million in lost productivity, tourism revenue, and emergency response measures. These are shown in the table below.

TABLE 13. Economic Costs of Infrastructure Decay by Category

Cost Category	Magnitude	Affected Stakeholders	Evidence Base	Potential Savings from Maintenance
Replacement vs. maintenance cost ratio	3-5x replacement cost	Utilities, governments, donors	Lifecycle cost models (Moriarty et al. 2019)	60-70% lifecycle cost reduction
Non-revenue water losses	30-50% of treated water (Nigeria); 25-40% (SA)	Utilities, paying customers	Utility performance data (Igbokwe et al. 2022)	15-25% of water recovered
Household water collection time	2-6 hours/day during interruptions	Households (disproportionately women/girls)	Time-use studies (Ekpo et al. 2021)	Increased productive hours, school attendance
Healthcare costs from waterborne disease	$100-500 million annually (Nigeria estimate)	Households, public health systems	Disease burden studies (Akinmoladun et al. 2019)	Reduced morbidity, mortality
Economic impact of major crisis (e.g., Day Zero)	$300-500 million (Cape Town, 2018)	Regional economy	Post-crisis assessments (Oluduro et al. 2020)	Crisis prevention savings

Source: Authors' synthesis based on Moriarty et al. (2019), Ekpo et al. (2021), Igbokwe et al. (2022), Akinmoladun et al. (2019), and Oluduro et al. (2020).

SOCIAL IMPACTS

The social impacts of infrastructure decay including inequitable access, disproportionate burden on vulnerable populations, and erosion of public trust represent perhaps the most enduring consequences of maintenance failure. According to Nwachukwu et al. (2020), water service disruptions affect wealthier households least, as they can afford alternative sources (bottled water, private tankers, storage systems) while poor households must either spend hours collecting unsafe water or pay a much higher proportion of their income to vendors. Tantoh et al. (2021) documented that women and girls bear the greatest social burden, as culturally assigned water collection responsibilities force girls to miss school and women to sacrifice income-generating activities during service outages.

In Ethiopia, Akinmoladun et al. (2019) observed that infrastructure decay perpetuates rural poverty, as lack of reliable water undermines small-scale agriculture, livestock, and home-based enterprises. The erosion of public trust, Igbokwe et al. (2022) argued, is a less visible but equally damaging consequence: when citizens pay taxes or tariffs but receive no water, trust in government erodes, undermining willingness to pay for future services and creating a downward spiral of disinvestment and decay. These are shown in the table below.

TABLE 14. Social Impacts of Infrastructure Decay by Vulnerable Group

Vulnerable Group	Specific Impact	Mechanism	Prevalence	Long-Term Consequence
Poor households	Higher water expenditure as % of income (5-20% vs. 1-3% for wealthy)	Forced to buy from informal vendors at 10-20x utility tariff	Very high (all countries)	Perpetuation of poverty cycle
Women	Time burden (2-6 hours/day collecting water)	Culturally assigned water collection responsibility remains regardless of distance/effort	Very high (all countries)	Lost economic opportunity; physical strain
Girls	School absenteeism and dropout	Water collection responsibilities during school hours; lack of sanitation facilities when water unavailable	High (rural Ethiopia, Nigeria, DRC)	Reduced educational attainment; intergenerational poverty
Children under 5	Mortality and morbidity from waterborne disease	Immune systems more vulnerable; dehydration more dangerous	Very high (all countries, especially DRC)	Excess preventable deaths
Rural communities	Economic isolation; inability to support enterprises	Unreliable water undermines agriculture, livestock, small business	High (Ethiopia, DRC, rural Nigeria)	Limited economic development
Public trust	Reduced willingness to pay tariffs or taxes	Citizens perceive no service regardless of payment	Moderate-High (especially SA, Nigeria)	Reduced revenue; continued decay cycle

Source: Authors' synthesis based on Nwachukwu et al. (2020), Tantoh et al. (2021), Akinmoladun et al. (2019), and Igbokwe et al. (2022)

GAPS IN EXISTING LITERATURE

Despite growing recognition of water infrastructure decay as a critical challenge across Sub-Saharan Africa, significant gaps persist in the existing literature. According to Igbokwe et al. (2022), most water sector research focuses on governance frameworks, climate adaptation, or technological innovation, leaving infrastructure maintenance as an understudied dimension. Akinmoladun et al. (2019) observed that even when studies document non-functionality rates, they rarely analyze the root causes of maintenance failure or compare patterns across multiple countries. Lehner et al. (2023) argued that the absence of critical, cross-national studies on decay means that policymakers lack the evidence base needed to design effective, scalable interventions that address the systemic nature of infrastructure deterioration rather than isolated technical failures.

The literature exhibits a pronounced bias toward new construction over maintenance systems. Nwachukwu et al. (2017) noted that research overwhelmingly examines infrastructure planning, design, and initial implementation, with comparatively little attention to the operational and maintenance phases that determine long-term sustainability. Ekpo et al. (2021) observed that studies evaluating water projects typically measure success by outputs (number of boreholes drilled, kilometers of pipe laid) rather than outcomes (functionality rates, service continuity, asset condition over time). This bias, Moriarty et al. (2019)

argued, mirrors the donor and government funding bias documented earlier, creating a self-reinforcing cycle where research priorities follow funding priorities, leaving maintenance systems systematically understudied and therefore underserved by evidence-informed policy.

Few comparative analyses exist across Sub-Saharan African countries, limiting the ability to identify context-specific versus generalizable solutions. Ogunbode et al. (2021) noted that most decay-related studies are single-country case studies, often focused on a single infrastructure type or locality, making it difficult to distinguish between idiosyncratic failures and systemic patterns that transcend national boundaries. Bassey et al. (2020) called for multi-country comparative research that examines how different governance structures, funding mechanisms, and institutional arrangements produce different maintenance outcomes across similar ecological and economic contexts. Without such comparative work, Tantoh et al. (2021) concluded, each country risks reinventing solutions to common problems, and the opportunity to learn from variation across the region remains largely untapped. These are shown in the table below.

TABLE 15. Summary of Gaps in Existing Literature on Water Infrastructure Decay

Gap Category	Specific Gap	Evidence of Gap	Consequence of Gap	This Study's Response
Critical cross-national studies	No dedicated, multi-country critical review focused specifically on water infrastructure decay and maintenance failures in Sub-Saharan Africa	Igbokwe et al. (2022) note most research focuses on governance, climate, or technology; Akinmoladun et al. (2019) observe rare root cause analysis; Lehner et al. (2023) call for cross-national evidence	Policymakers lack evidence base for systemic interventions	This study provides a critical, multi-country review across Nigeria, Ethiopia, DRC, and South Africa
Maintenance vs. new construction	Research bias toward infrastructure planning and implementation; maintenance systems understudied	Nwachukwu et al. (2017) note research focus on outputs (boreholes drilled) not outcomes (functionality); Ekpo et al. (2021) observe project evaluation bias; Moriarty et al. (2019) identify research-funding cycle	Maintenance remains under-evidenced and therefore under-prioritized	This study focuses specifically on maintenance systems, decay patterns, and failure mechanisms
Comparative analysis across countries	Few studies compare decay patterns, maintenance systems, or outcomes across multiple Sub-Saharan countries	Ogunbode et al. (2021) note predominance of single-country studies; Bassey et al. (2020) call for multi-country comparative research; Tantoh et al. (2021) warn of reinventing solutions	Limited learning from cross-country variation; context-specific vs. generalizable solutions unclear	This study systematically compares four countries representing West, East, Central, and Southern Africa

Source: Authors' synthesis based on Literature

RESEARCH METHODOLOGY

RESEARCH DESIGN

This study adopts a desk research methodology, also known as secondary research, to provide a critical review of water infrastructure decay and facility maintenance across Sub-Saharan Africa and Morocco. According to Saunders et al. (2019), desk research is particularly suited to studies seeking to leverage diverse existing datasets and literature to address complex, multi-dimensional challenges where primary data collection may be resource-prohibitive or logistically infeasible. Creswell (2014) emphasized that this approach allows researchers to synthesize findings from multiple sources, identify patterns across contexts, and generate new insights without replicating data collection efforts. As applied to this study, desk research enables systematic comparison of infrastructure decay patterns across Nigeria, Ethiopia, Democratic Republic of Congo, South Africa, and Morocco representing West, East, Central, Southern, and North Africa respectively.

The methodology follows a systematic, iterative process comprising three key phases: data identification, data evaluation, and data synthesis, consistent with the framework established in the original paper. Yin (2018) recommended this phased approach for secondary research, arguing that it ensures rigor and replicability even when no primary data are collected. Bryman (2016) noted that desk research, when properly executed, can achieve analytical depth comparable to primary research, particularly for policy-relevant topics like infrastructure decay where extensive evaluation data already exist. By applying this methodology specifically to the decay and maintenance lens while expanding geographic coverage to include Morocco as a North African comparator this review offers a novel contribution that spans the continent's five regions, enabling meaningful cross-regional analysis.

DATA SOURCES

Academic literature from Scopus, Web of Science, and Google Scholar serves as the primary data source, drawing on peer-reviewed journals, conference proceedings, and books on water infrastructure decay across the five focus countries (Creswell, 2014; Saunders et al. 2019). Foundational works (Bryman, 2016; Yin, 2018) provide theoretical grounding, while recent empirical studies (e.g., Akinmoladun et al. 2019; Igbokwe et al. 2022) supply country-specific evidence. Institutional reports from the World Bank, African Development Bank, and WHO/UNICEF JMP offer standardized, cross-nationally comparable data on water access, infrastructure investment, and sector performance, with additional EU and AFD reports providing context for Morocco's National Water Strategy (Olufemi et al. 2020; Ait Kadi & Ziyad, 2018).

Country-specific utility reports and audits from Nigeria (RuWASA), Ethiopia (MoWIE), DRC (REGIDESO), South Africa (DWS), and Morocco (ONEE) provide granular operational data on maintenance budgets, non-revenue water, and asset age (Yin, 2018; Saunders et al. 2019). NGO and development partner evaluations (WaterAid, IRC WASH, UNICEF, USAID, DFID, GIZ, AFD) offer implementation-level insights on spare parts supply chains, community-based maintenance models, and functionality rates, with triangulation across sources mitigating potential bias (Flick, 2018; Cooper & Schindler, 2014). For Morocco, AFD and GIZ reports provide additional insights on desalination, wastewater reuse, and dam maintenance systems (Taleb, 2006; Alaoui, 2013). These are demonstrated in the figure below.

Country	Region	Academic Literature Availability	Institutional Reports	Utility Reports Availability	NGO Evaluations	Language Considerations
Nigeria	West Africa	High	High (World Bank, AFDB, JMP)	Moderate (RuWASA, state boards)	High (WaterAid, UNICEF, USAID)	English
Ethiopia	East Africa	Moderate-High	High (World Bank, AFDB, JMP)	Moderate (MoWIE, regional utilities)	High (UNICEF, IRC, DFID)	English
DRC	Central Africa	Low-Moderate	Moderate (World Bank, UN reports)	Low (REGIDESO limited data)	Moderate (UNICEF, MSF, World Bank)	French/English
South Africa	Southern Africa	High	High (World Bank, AFDB, DWS)	High (DWS, municipal water boards, SALGA)	High (WaterAid, IRC, GIZ)	English
Morocco	North Africa	Moderate-High	High (World Bank, AFDB, EU, AFD)	High (ONEE, regional authorities)	Moderate (GIZ, AFD, World Bank)	Arabic/ English/French
Egypt	North Africa	Moderate-High	High (World Bank, AFDB, EU, AFD)	Moderate-High (NWRC, Holding Company)	Moderate (GIZ, AFD, World Bank, USAID)	Arabic/ English/French

FIGURE 1. Data Source Availability by each selected Country
Source: Authors' synthesis based on literature availability assessment and country-specific sources

SEARCH STRATEGY

The search strategy employs targeted keywords and Boolean operators to systematically identify relevant literature across academic databases and institutional repositories across all five focus countries. According to Creswell (2014), a well-defined search strategy ensures reproducibility and reduces the risk of omitting critical sources. Primary keywords include: "water infrastructure decay," "facility maintenance," "non-functional water points," "asset management Africa," "water infrastructure Sub-Saharan Africa," and for Morocco specifically: "gestion des infrastructures hydrauliques," "maintenance des réseaux d'eau," and "ONEE performance reports." Saunders et al. (2019) recommended using Boolean operators (AND, OR, NOT) to refine searches for example, ("water infrastructure" OR "water supply") AND ("decay" OR "deterioration" OR "failure") AND ("Nigeria" OR

"Ethiopia" OR "DRC" OR "South Africa" OR "Morocco").

Inclusion and exclusion criteria are applied systematically to ensure source relevance and quality across the diverse geographic contexts. Flick (2018) argued that explicit criteria enhance transparency and reduce selection bias in desk research.

Inclusion criteria require:

1. publication date within the last 15 years (2010-2025), except for foundational theoretical works;
2. direct relevance to water infrastructure, decay, maintenance, or asset management;
3. geographic focus on Nigeria, Ethiopia, DRC, South Africa, or Morocco; and
4. publication in peer-reviewed journals, by credible institutional sources, or by recognized NGOs.

Exclusion criteria eliminate:

1. studies focused exclusively on water quality, sanitation, or hygiene without infrastructure dimensions;
2. purely theoretical papers without empirical application to the focus countries;
3. opinion pieces or editorials without data; and
4. non-English publications (with limited inclusion of French-language sources for Morocco and DRC where English sources are scarce).

Maxwell (2013) noted that iterative searching reviewing citations of identified sources and conducting forward citation tracking complements database searches and captures influential works that keyword searches may miss, particularly for North African contexts where literature may be published in French or Arabic.

CASE STUDY SELECTION

The selection of Nigeria, Ethiopia, Democratic Republic of Congo, South Africa, and Morocco for this case study is based on their strategic geographic distribution across Africa's five regions and their diverse socio-economic and infrastructure contexts. According to Yin (2018), case study selection in comparative research should prioritize geographic diversity and variation on key dimensions of interest in this instance, water infrastructure condition, maintenance systems, governance capacity, and income levels. Saunders et al. (2019) recommended selecting cases that represent the full range of variation on dependent variables (here, infrastructure decay severity) to enable meaningful comparison and identification of generalizable patterns. As applied to this study, the five countries span North Africa (Morocco), West Africa (Nigeria), East Africa (Ethiopia), Central Africa (DRC), and Southern Africa (South Africa), ensuring comprehensive continental representation while capturing dramatic variation in infrastructure development trajectories and current decay levels.

The selected countries exhibit significant contrasts in income levels, governance quality, and infrastructure condition, enabling robust comparative analysis of decay drivers. Creswell (2014) argued that comparative case studies are most powerful when cases differ substantially on contextual factors, as this allows researchers to identify which decay mechanisms are universal versus context-specific. Nigeria, South Africa, and Morocco represent Africa's largest and most diversified economies (GDP rankings: Nigeria #1, South Africa #2, Morocco #5), yet their infrastructure condition varies dramatically: South Africa and Morocco maintain relatively functional systems despite decay, while Nigeria struggles with severe fragmentation and underfunding (African Development Bank, 2018).

Ethiopia represents a lower-income but rapidly growing economy (GDP #6) with severe rural decay but emerging urban investments, while DRC represents a fragile state (GDP #4 but low per capita) with near-total infrastructure collapse despite abundant water resources (Tshimanga et al. 2022). This diversity, Bryman (2016) noted, allows the study to distinguish between decay causes linked to income (e.g., funding availability) versus those linked to governance (e.g., corruption, fragmentation) versus those linked to environmental factors (e.g., aridity, flooding) insights impossible from single-country studies. These are demonstrated in the figure below.

Selection Criterion	Nigeria	Ethiopia	DRC	South Africa	Morocco	Rationale for Inclusion
Geographic Region	West Africa	East Africa	Central Africa	Southern Africa	North Africa	Continental representation across all five African regions
GDP Ranking (Africa)	#1	#6	#4	#2	#5	Variation across major economies; includes both high and lower-middle income
Population (2025)	~232M	~132M	~109M	~64M	~38M	Variation from large to medium; all significant markets
Water Access (% national)	60–70%	40–50%	30–40%	85–90%	85–90%	Wide range from severe deficit to moderate access
Infrastructure Condition	Severe decay	Severe (rural); Moderate (urban)	Extreme decay	Moderate-Severe (aging)	Moderate (urban); Moderate-Severe (rural)	Variation from collapse to functional but decaying
Governance Quality	Fragmented/ Weak	Centralized/ Limited	Near-absent	Progressive but uneven	Robust but fragmented	Variation from functional to failed governance
Primary Decay Driver	Corruption; fragmentation	Drought; supply chains	Conflict; neglect	Aging; staff shortages	Aquifer overuse; agricultural pollution	Enables comparison of different causal mechanisms
Technological Capacity	Low-Moderate	Low-Moderate	Very Low	Moderate-High	Moderate-High	Variation enables technology-adoption comparisons
Data Availability	High	Moderate-High	Low-Moderate	High	Moderate-High	Feasibility across all five countries

FIGURE 2. Case Study Selection Criteria and Country Characteristics
Source: Authors' synthesis based on African Development Bank (2018), Tshimanga et al. (2022), Creswell (2014), Yin (2018), Saunders et al. (2019), Bryman (2016), and country-specific literature cited in Section 4

DATA ANALYSIS

Data analysis for this review employs three complementary approaches: thematic analysis, comparative analysis across the five selected countries, and a root cause analysis framework. Thematic analysis will be conducted using NVivo software (or manual coding where software is unavailable) to identify recurring patterns, themes, and gaps in the literature on water infrastructure decay and maintenance failures, following the systematic coding procedures recommended by Creswell (2014) and Maxwell (2013).

Comparative analysis across Nigeria, Ethiopia, DRC, South Africa, and Morocco will highlight similarities and differences in decay patterns, maintenance systems, governance arrangements, and infrastructure outcomes, enabling context-specific insights while drawing generalizable conclusions about which decay drivers are universal versus context-dependent (Yin, 2018; Bryman, 2016).

A root cause analysis framework will be applied to distinguish between immediate causes (e.g., lack of spare parts, staff shortages), underlying causes (e.g., inadequate budgets, weak institutions), and systemic causes (e.g., donor bias, political economy of ribbon-cutting), providing a structured approach to understanding why decay persists and informing targeted recommendations for policy and practice (Saunders et al. 2019; Flick 2018).

CASE STUDY FINDINGS

NIGERIA

Nigeria experiences moderate to high water infrastructure decay, particularly in the northern regions and major urban centers like Lagos, Kano, and Abuja. According to Akinmoladun et al. (2019), aging piped networks many installed during the 1960s and 1970s suffer from extensive corrosion, leakage rates of 30-50%, and frequent pipe bursts that disrupt service for days or weeks. Nwachukwu et al. (2020) documented that most water treatment plants operate at less than 50% of designed capacity due to neglected maintenance, inadequate chemical supplies, and outdated equipment that cannot be repaired due to lack of spare parts. Igbokwe et al. (2022) reported that in rural areas, boreholes and handpumps exhibit non-functionality rates exceeding 40%, with repairs delayed by months due to broken supply chains for spare parts like seals, riser pipes, and pump cylinders.

Governance of water infrastructure in Nigeria remains fragmented across federal, state, and local agencies, creating accountability gaps for maintenance. Bassey et al.

(2020) observed that the federal government focuses on water policy and transboundary rivers, state governments own and operate urban water utilities, and local governments are nominally responsible for rural water points but no level has clear, enforceable maintenance mandates. Ekpo et al. (2021) documented that corruption diverts maintenance budgets through inflated procurement contracts and ghost workers, leaving utilities with insufficient funds for routine repairs. Ogunbode et al. (2021) noted that state water boards lack trained technicians, with vacancies exceeding 30% in many utilities, and those employed rarely receive updated training on modern equipment or asset management systems.

Sustainability of water infrastructure in Nigeria is severely threatened by chronic underfunding and environmental stressors. According to Moriarty et al. (2019), annual maintenance budgets average only 5-8% of capital replacement value, far below the 15-20% needed to prevent asset deterioration. Olawale et al. (2021) documented that climate change intensifies decay through increased flooding, which scours pipe foundations and inundates pump stations, and more frequent droughts that lower groundwater tables, causing boreholes to fail. Despite these challenges, Nwachukwu et al. (2017) identified opportunities in community-based maintenance models, where local area mechanics (LAMs) have successfully reduced handpump downtime in pilot areas, and in public-private partnerships emerging in Lagos and Abuja to finance infrastructure rehabilitation. These are shown in the table below.

TABLE 16. Summary of Water Infrastructure Decay and Maintenance in Nigeria

Dimension	Status	Key Findings	Primary Causes	Data Sources
Infrastructure Condition	Severe decay	Piped networks: 30-50% leakage; treatment plants: <50% capacity; rural non-functionality: >40%	Aging (50+ years); corrosion; lack of spare parts	Akinmoladun et al. (2019); Nwachukwu et al. (2020)
Governance	Fragmented	Federal, state, local split mandates; no clear maintenance accountability	Weak coordination; overlapping jurisdictions	Igbokwe et al. (2022); Bassey et al. (2020)
Financial	Severely underfunded	Maintenance budget: 5-8% of need (vs. 15-20% required)	Corruption; political neglect; low tariff recovery	Moriarty et al. (2019); Ekpo et al. (2021)
Technical Capacity	Weak	30%+ technician vacancies; outdated skills	Poor training; low salaries; migration to private sector	Ogunbode et al. (2021)
Environmental Stressors	High	Flooding scours pipes; droughts lower groundwater	Climate change; poor drainage; deforestation	Olawale et al. (2021)
Opportunities	Emerging	Community area mechanics; PPPs in major cities	Pilot success; donor interest; reform momentum	Nwachukwu et al. (2017)

Source: Authors' synthesis based on Akinmoladun et al. (2019), Nwachukwu et al. (2017, 2020), Igbokwe et al. (2022), Bassey et al. (2020), Ekpo et al. (2021), Ogunbode et al. (2021), Moriarty et al. (2019), and Olawale et al. (2021)

The foundational governance, sustainability, and technology frameworks for African water infrastructure established by Kumo et al. (2025) provide the backdrop against which infrastructure decay and maintenance failures must be understood, while Ali et al. (2026) demonstrated that critical success factors such as governance, stakeholder engagement, and financial management are essential for preventing such decay in Nigeria. Complementing these findings, Dalibi and Bello (2017) examined how external Chinese infrastructure financing influences infrastructure outcomes and maintenance sustainability, and Ali Kumo et al. (2021) revealed how competing priorities in developing countries often relegate maintenance to secondary status behind new construction.

Further, Dalibi et al. (2020) showed how mega-project dynamics (like water projects) affect long-term asset management and decay patterns, while Ali (2025) confirmed that maintenance systems and institutional capacity are as important as initial construction quality for sustainable water service delivery across Sub-Saharan Africa.

ETHIOPIA

Ethiopia faces severe water infrastructure decay, particularly in arid and semi-arid regions where drought and reliance on rain-fed systems amplify vulnerability. According to Tantoh et al. (2021), rural water points including handpumps, boreholes, and springs exhibit non-functionality rates of 30-50% at any given time, with many constructed within the last decade already in disrepair. Ekpenyong et al. (2020) documented that the Afar and Somali regions experience the highest failure rates, where deep boreholes equipped with submersible pumps fail due to generator breakdowns, lack of diesel fuel, and absence of trained operators. Mubiala et al. (2022) reported that sedimentation from deforestation in highland watersheds fills reservoirs and clogs intake screens, reducing storage capacity and requiring frequent, costly cleaning that cash-strapped utilities cannot perform.

Governance of water infrastructure in Ethiopia is centralized under the Ministry of Water, Irrigation, and Energy (MoWIE), but limited capacity at regional and woreda (district) levels undermines maintenance delivery. Igbokwe et al. (2022) observed that while national policies prioritize universal access, implementation suffers from weak coordination between federal, regional, and local authorities, with maintenance responsibilities poorly defined. Bantider et al. (2023) documented that transboundary disputes over the Nile River particularly related to the Grand Ethiopian Renaissance Dam divert policy attention and resources away from domestic infrastructure maintenance. Tantoh et al. (2021) noted that WASH committees, designed to manage rural water points at community level, often lack training, tools, and financial resources, leaving many non-functional without any mechanism for repair.

Sustainability of water resources in Ethiopia is strained by seasonal variability, overreliance on the Nile, and poor watershed management practices. According to Gedehaw et al. (2023), deforestation accelerates soil erosion, increasing sedimentation rates in reservoirs and shortening their operational lifespan by decades. Heyi et al. (2022) documented that climate change intensifies hydrological variability, with more frequent and severe droughts reducing groundwater recharge and surface flows, causing boreholes and intakes to fail during dry seasons. Despite these challenges, opportunities exist in low-cost technologies including solar-powered pumps and community-managed schemes which have shown success in pilot areas, and in regional cooperation through initiatives like the Nile Basin Initiative, which could unlock maintenance funding and technical assistance (Nwagboso et al. 2020). These are shown in the table below.

TABLE 17. Summary of Water Infrastructure Decay and Maintenance in Ethiopia

Dimension	Status	Key Findings	Primary Causes	Data Sources
Infrastructure Condition	Severe (rural); Moderate (urban)	Rural non-functionality: 30-50%; handpumps fail within 3-7 years; sedimentation reduces reservoir capacity	Drought; lack of spare parts; poor construction; sedimentation	Tantoh et al. (2021); Ekpenyong et al. (2020); Mubiala et al. (2022)
Governance	Centralized but weak	Ministry of Water, Irrigation, and Energy has limited regional capacity; WASH committees under-resourced	Weak coordination; poorly defined local maintenance roles	Igbokwe et al. (2022); Bantider et al. (2023); Tantoh et al. (2021)
Transboundary	High complexity	GERD diverts attention from domestic maintenance; upstream-downstream tensions	Nile River politics; regional hydropower priorities	Nwagboso et al. (2020)
Environmental Stressors	High	Deforestation accelerates sedimentation; drought reduces groundwater recharge	Climate change; land use change; population pressure	Gedehaw et al. (2023); Heyi et al. (2022)
Technical Capacity	Limited	Shortage of trained technicians at woreda level; no local spare parts manufacturing	Weak training systems; import dependency	Tantoh et al. (2021)
Opportunities	Emerging	Solar-powered pumps; community-managed schemes; Nile Basin Initiative cooperation	Pilot successes; donor support; regional frameworks	Nwagboso et al. (2020)

Source: Authors' synthesis based on Tantoh et al. (2021), Ekpenyong et al. (2020), Mubiala et al. (2022), Igbokwe et al. (2022), Bantider et al. (2023), Gedehaw et al. (2023), Heyi et al. (2022), and Nwagboso et al. (2020)

DEMOCRATIC REPUBLIC OF CONGO (DR CONGO)

The Democratic Republic of Congo possesses abundant water resources including the Congo River basin, the world's second-largest river system yet suffers from extreme infrastructure decay and minimal access to safe water. According to Tshimanga et al. (2022), less than 30% of the population has access to basic drinking water services, and much of the colonial-era infrastructure in Kinshasa and other cities has collapsed entirely due to decades of neglect, conflict, and underinvestment. Bédécarrats et al. (2019) documented that in Kinshasa's outskirts, residents rely on unsafe wells, rivers, and water vendors because formal piped networks, built in the 1950s, have disintegrated without any maintenance for 30+ years. Kapembo et al. (2022) reported that even where boreholes exist, non-functionality rates exceed 70% in many rural areas, with broken handpumps and pumps left unrepaired for years or decades.

Governance of water infrastructure in DRC is profoundly weak, undermined by corruption, political instability, and near-absence of institutional capacity. Kayembe et al. (2018) observed that the public water utility, REGIDESO, is technically bankrupt, unable to pay staff, purchase chemicals, or procure spare parts, and operates primarily on donor-funded emergency interventions rather than systematic maintenance. Bagula et al. (2022) documented that conflict in eastern provinces has destroyed water infrastructure and prevented any maintenance access for years, with communities in conflict zones entirely reliant on unprotected surface water. Chishugi et al. (2021) noted that even where peace exists, the absence of local government capacity means no entity at provincial or territorial level has maintenance mandates, budgets, or technical skills.

Sustainability of water resources in DRC is threatened by mining contamination, poor waste management, and deforestation of the Congo Basin. According to Kayembe et al. (2018), mining activities in Katanga and other regions release heavy metals and acid mine drainage into water sources, and collapsed treatment infrastructure cannot remove these contaminants. Tshimanga et al. (2022) documented that deforestation in the Congo Basin disrupts hydrological cycles, reducing dry-season flows and increasing sedimentation in rivers used for water supply. Despite these challenges, Bates et al. (2024) identified opportunities in leveraging the country's vast water resources through regional initiatives like the Congo Basin Water Resources Commission, and in targeted investments in decentralized systems such as solar-powered kiosks and community-managed boreholes that bypass the failed centralized utility model. These are shown in the table below.

TABLE 18. Summary of Water Infrastructure Decay and Maintenance in DR Congo

Dimension	Status	Key Findings	Primary Causes	Data Sources
Infrastructure Condition	Extreme decay	Access: <30%; urban networks collapsed (colonial-era, 1950s); rural non-functionality: >70%	Decades of neglect; conflict; no investment	Tshimanga et al. (2022); Bédécarrats et al. (2019); Kapembo et al. (2022)
Governance	Near-absent	REGIDESO bankrupt; no provincial maintenance capacity; conflict zones inaccessible	Corruption; political instability; no institutional capacity	Kayembe et al. (2018); Bagula et al. (2022); Chishugi et al. (2021)
Financial	Zero functional budget	No maintenance budget; donor-dependent emergency interventions only	State collapse; no tariff collection; donor bias toward new construction	Kayembe et al. (2018)
Environmental Stressors	High	Mining contamination (heavy metals); deforestation; sedimentation	Mining activities; land use change; climate variability	Kayembe et al. (2018); Tshimanga et al. (2022)
Technical Capacity	Severely limited	No trained technicians; no spare parts supply chains; no local manufacturing	Conflict; education collapse; import dependency	Bagula et al. (2022)
Opportunities	Potential	Congo Basin regional cooperation; decentralized solar-powered kiosks; community boreholes	Donor interest; abundant water resources; regional frameworks	Bates et al. (2024)

Source: Authors' synthesis based on Tshimanga et al. (2022), Bédécarrats et al. (2019), Kapembo et al. (2022), Kayembe et al. (2018), Bagula et al. (2022), Chishugi et al. (2021), and Bates et al. (2024)

MOROCCO

Morocco exhibits a contrasting water infrastructure profile relative to its Sub-Saharan counterparts, featuring relatively robust systems including extensive dams, irrigation networks, and urban water supply yet still faces significant decay challenges driven by arid conditions and agricultural over-extraction. According to Ait Kadi and Ziyad (2018), Morocco has invested heavily in water infrastructure, constructing over 140 large dams with total storage capacity exceeding 18 billion cubic meters, along with modern irrigation systems and desalination plants. Olufemi et al. (2020) documented that urban water utilities, particularly ONEE (Office National de l'Eau et de l'Électricité), maintain relatively high service standards, with non-revenue water rates of 20-25% in major cities lower than South Africa but higher than European benchmarks. However, Taleb (2006) noted that aging secondary networks in smaller cities and rural towns suffer from leaks, pressure losses, and meter inaccuracies, with maintenance backlogs growing due to underinvestment.

Governance of water infrastructure in Morocco is relatively robust, with clear institutional mandates and strategic planning frameworks such as the National Water Strategy. According to Alaoui (2013), the Ministry of Equipment and Water oversees water resources planning, while ONEE manages urban water supply and sanitation, and regional agricultural water users' associations manage irrigation systems. Ben-Daoud et al. (2021) observed that decentralized governance faces coordination challenges, particularly between national agencies and provincial authorities, leading to uneven maintenance performance across regions. Alitane et al. (2022) documented that transboundary water issues particularly upstream dam construction by Algeria and climate-driven flow reductions in the Moulouya and Drâa basins complicate long-term infrastructure planning and require adaptive maintenance strategies.

Sustainability of water resources in Morocco is severely stressed by aquifer overuse, agricultural pollution, and climate change. According to Attar et al. (2022), groundwater abstraction exceeds recharge by 2-3 times in key agricultural regions like Souss-Massa, leading to aquifer depletion, saltwater intrusion in coastal areas, and progressive abandonment of boreholes that fail due to falling water tables. Olufemi et al. (2020) documented that agricultural runoff particularly nitrates and pesticides contaminates surface and groundwater sources, and treatment plants lack capacity to remove these contaminants when equipment is poorly maintained. Despite these challenges, Khadija et al. (2024) identified Morocco as a regional leader in technological innovation, with significant investments in desalination (including the large-scale Agadir desalination plant), wastewater reuse for agricultural irrigation (treated volume tripled since 2015), and renewable energy-powered pumping systems that reduce operational costs and carbon footprint. These are shown in the table below.

TABLE 19. Summary of Water Infrastructure Decay and Maintenance in Morocco

Dimension	Status	Key Findings	Primary Causes	Data Sources
Infrastructure Condition	Moderate (urban); Moderate-Severe (rural/ small towns)	140+ large dams; urban non-revenue water: 20-25%; secondary networks decaying; rural systems under-maintained	Aging secondary networks; underinvestment in rural areas; agricultural over-extraction	Ait Kadi and Ziyad (2018); Olufemi et al. (2020); Taleb (2006)
Governance	Robust but fragmented	National Water Strategy; ONEE manages urban systems; coordination challenges with provinces	Centralized planning; uneven decentralization; transboundary pressures	Alaoui (2013); Ben-Daoud et al. (2021); Alitane et al. (2022)
Financial	Moderate	Maintenance budgets higher than Sub-Saharan Africa but below European benchmarks; agricultural subsidies distort water pricing	Low water tariffs; political sensitivity of water pricing; competing investment priorities	Olufemi et al. (2020)
Environmental Stressors	Severe	Aquifer over-extraction (2-3x recharge); agricultural pollution (nitrates); saltwater intrusion; climate-driven flow reduction	Irrigation demand; climate change; land use practices	Attar et al. (2022); Olufemi et al. (2020)
Technical Capacity	Moderate-High	ONEE has trained technicians; remote monitoring systems; but capacity gaps in rural areas	Urban-rural divide; limited local manufacturing for spare parts	Khadija et al. (2024); Taleb (2006)
Opportunities	Significant	Desalination (Agadir plant); wastewater reuse (tripled since 2015); renewable energy pumps; solar desalination	Technological leadership; donor support (AFD, World Bank, GIZ); political will	Khadija et al. (2024); Ait Kadi and Ziyad (2018)

Source: Authors' synthesis based on Ait Kadi and Ziyad (2018), Olufemi et al. (2020), Taleb (2006), Alaoui (2013), Ben-Daoud et al. (2021), Alitane et al. (2022), Attar et al. (2022), and Khadija et al. (2024)

SOUTH AFRICA

South Africa possesses the most advanced water infrastructure among the five focus countries, yet faces severe decay challenges characterized by aging assets, non-revenue water losses, and recurring service crises including Cape Town's 2018 "Day Zero" near-miss. According to Oluduro et al. (2020), much of the country's water infrastructure including large dams, treatment plants, and piped networks was built during the apartheid era (pre-1994) and has exceeded its design life by decades, with deferred maintenance accelerating deterioration. Sogunro et al. (2020) documented that non-revenue water losses average 25-40% nationally, exceeding 50% in some municipalities, due to leaking pipes, illegal connections, and meter inaccuracies. Adom and Simatele (2022) reported that wastewater treatment works across the country are in critical condition, with many breaching effluent quality standards and some completely non-operational.

Governance of water infrastructure in South Africa features progressive legal frameworks including the National Water Act (1998) and Water Services Act (1997) but implementation is hampered by aging infrastructure, maintenance funding gaps, and skilled staff shortages. According to Claassen (2013), the country's water rights and allocation systems are among the most sophisticated in Africa, yet municipal capacity to operate and maintain infrastructure varies widely, with wealthy metros (Cape Town, Johannesburg, Durban) performing well while many rural and small-town municipalities fail entirely. van Koppen and Schreiner (2014) observed that the 2018 "Day Zero" crisis exposed systemic vulnerabilities: Cape Town's infrastructure was adequate, but drought, demand growth, and maintenance neglect nearly caused collapse. Molobela and Sinha (2011) documented that maintenance backlogs across municipalities exceed ZAR 30 billion (approximately $1.6 billion), with backlog growing annually due to underfunding.

Sustainability of water resources in South Africa is severely stressed by overextraction, pollution, and climate variability. According to Mukheibir (2008), groundwater aquifers are over-abstracted in many regions, and acid mine drainage contaminates water sources in Gauteng and Mpumalanga. Nelson and Juhász (2018) documented that climate change intensifies hydrological variability, with more frequent and severe droughts like the 2015-2018 Western Cape drought that brought Cape Town to Day Zero. Despite these challenges, opportunities exist in technological innovations including desalination (Cape Town's temporary desalination plants), water reuse programs (eWastewater recycling in eThekwini Municipality), and smart water meters (deployed in Johannesburg and Cape Town), alongside public awareness campaigns that successfully reduced per capita water use during the drought.

KEY INSIGHTS FROM CASES

The five case studies reveal a clear continuum of infrastructure decay severity across Africa, ranging from near-total collapse in DRC to moderate decay in Morocco, with Nigeria, Ethiopia, and South Africa occupying intermediate positions. A common pattern across all countries is the persistent gap between maintenance needs and actual budgets, with even relatively well-resourced South Africa and Morocco allocating only 8-12% and 6-10% of capital value to maintenance respectively, falling short of the 15-20% benchmark recommended by Moriarty et al. (2019).

Notably, countries with fragmented or weak governance (Nigeria, DRC) experience more severe decay than those with centralized (Ethiopia) or progressive but uneven (South Africa) governance, suggesting that institutional coherence rather than simply funding levels is a critical determinant of infrastructure outcomes. Morocco's relatively better performance, despite significant environmental stressors, demonstrates that strategic investment in technology (desalination, wastewater reuse) and clear institutional mandates can partially offset the challenges of aridity and agricultural over-extraction (Khadija et al. 2024; Ait Kadi & Ziyad, 2018).

Environmental stressors compound governance and financial deficits in all five countries, but with different manifestations and intensities. In Ethiopia and South Africa, climate-induced droughts have triggered acute crises including Cape Town's "Day Zero" that exposed underlying maintenance neglect and forced emergency responses (Oluduro et al. 2020; Heyi et al. 2022). In Nigeria and DRC, flooding and sedimentation from deforestation accelerate physical decay, overwhelming already underfunded maintenance systems (Olawale et al. 2021; Tshimanga et al. 2022).

Morocco faces a distinct set of environmental pressures, primarily aquifer over-extraction (2-3 times recharge rates) and agricultural pollution, which degrade water quality and reduce the lifespan of boreholes and treatment equipment (Attar et al. 2022). Across all cases, the interaction between environmental stressors and weak maintenance systems creates a vicious cycle: decay reduces system resilience to climate shocks, and climate shocks accelerate further decay, permanently eroding infrastructure capacity.

Despite these challenges, each country presents unique opportunities that could be scaled or adapted across the continent. South Africa's experience with desalination, water reuse, and smart water meters demonstrates that technological innovation can mitigate scarcity and improve efficiency, though these solutions remain concentrated in wealthy metros (Oluduro et al. 2020). Morocco's leadership in renewable energy-powered desalination and wastewater reuse with treated volume tripled since 2015 offers a model for other water-scarce nations, particularly in North and Southern Africa (Khadija et al. 2024).

Nigeria's community-based area mechanics and Ethiopia's solar-powered pumps illustrate low-cost, decentralized approaches suitable for rural contexts where centralized systems have failed (Nwachukwu et al. 2017; Nwagboso et al. 2020). For DRC, the most extreme case, opportunities lie not in incremental reforms but in radical decentralization bypassing the failed state utility REGIDESO in favor of community-managed boreholes and donor-supported kiosks that can function independently of national systems (Bates et al. 2024). The variation across these five countries suggests that no single solution exists; rather, effective maintenance strategies must be tailored to local governance capacity, infrastructure maturity, and environmental context. These are shown in the table below.

TABLE 20. Summary of Water Infrastructure Decay and Maintenance in South Africa

Dimension	Status	Key Findings	Primary Causes	Data Sources
Infrastructure Condition	Moderate-Severe	Non-revenue water: 25-40% (50%+ in some municipalities); WWTP failures widespread; assets beyond design life	Aging (pre-1994 apartheid-era); deferred maintenance; population growth	Oluduro et al. (2020); Sogunro et al. (2020); Adom and Simatele (2022)
Governance	Progressive laws; weak implementation	National Water Act (1998) strong; municipal capacity varies widely; Day Zero exposed vulnerabilities	Uneven municipal capacity; funding gaps; staff shortages	Claassen (2013); van Koppen and Schreiner (2014); Molobela and Sinha (2011)
Financial	Severe backlog	Maintenance backlog: >R30 billion ($1.6B); growing annually	Underfunding; competing priorities; low tariffs in poor municipalities	Molobela and Sinha (2011)
Environmental Stressors	High	Over-extraction; acid mine drainage; drought intensification	Climate change; mining legacy; groundwater depletion	Mukheibir (2008); Nelson and Juhász (2018)
Technical Capacity	Variable	Strong in metros (Cape Town, Jhb, Durban); critically weak in rural/small towns	Uneven investment; skills flight from small municipalities	Adom and Simatele (2022)
Opportunities	Significant	Desalination; water reuse; smart meters; public awareness	Technological innovation; crisis-driven reform; private sector engagement	Oluduro et al. (2020); Sogunro et al. (2020)

Source: Authors' synthesis based on Oluduro et al. (2020), Sogunro et al. (2020), Adom and Simatele (2022), Claassen (2013), van Koppen and Schreiner (2014), Molobela and Sinha (2011), Mukheibir (2008), and Nelson and Juhász (2018)

ANALYSIS AND DISCUSSION

The case study findings reveal that water infrastructure decay across Nigeria, Ethiopia, DRC, South Africa, and Morocco is not a collection of isolated technical failures but a systemic crisis driven by predictable patterns of underfunding, institutional weakness, and perverse political incentives. While the severity and manifestation of decay vary significantly across countries from near-total collapse in DRC to moderate but persistent decay in Morocco the underlying mechanisms exhibit striking similarities that transcend geographic and income differences. This section analyzes cross-cutting themes, presents a multi-level root cause framework, and discusses the implications of these findings for policy and practice across the African continent.

CROSS-CUTTING THEMES ACROSS FIVE COUNTRIES

The comparative analysis reveals five cross-cutting themes that characterize infrastructure decay across all five countries, regardless of income level or governance tradition. The "build-neglect-rebuild" cycle emerges as the most pervasive pattern: donors and governments systematically prioritize new construction over maintenance, allocating 80-90% of WASH funding to new assets while leaving maintenance budgets at 2-12% of capital value far below the 15-20% benchmark needed for asset preservation (Moriarty et al. 2019; Ekpo et al. 2021). This bias is reinforced by political economy dynamics where politicians and donors receive visible credit for inaugurating new boreholes, dams, or treatment plants, while maintaining existing assets produces no ribbon-cutting opportunities (Nwachukwu et al. 2017). The consequence is predictable: infrastructure fails prematurely (within 5-10 years), requiring costly replacement at 3-5 times the cost of proper maintenance, a pattern documented across Nigeria, Ethiopia, DRC, South Africa, and Morocco (Ait Kadi & Ziyad, 2018; Oluduro et al. 2020).

Institutional fragmentation, corruption, supply chain failures, skills shortages, and data gaps compound the maintenance deficit across all five countries. Responsibilities for water infrastructure are split across multiple agencies with poor coordination most severely in Nigeria (3+ agency levels) and DRC (near-absent coordination), but also evident in Ethiopia's centralized but weak system, South Africa's municipal variation, and Morocco's urban-rural coordination gaps (Igbokwe et al. 2022; Ben-Daoud et al. 2021). Corruption diverts maintenance budgets through inflated procurement contracts, ghost workers, and diversion of spare parts, with documented prevalence highest in Nigeria and DRC but present to varying degrees across all countries (Kayembe et al. 2018; Ekpo et al. 2021).

Supply chain failures particularly lack of spare parts for imported pumps and treatment equipment produce extended downtime, transforming minor, repairable issues into permanent failures (Bassey et al. 2020). Skills shortages (15-70% technician vacancies across countries) and data gaps (no asset registers, no condition monitoring systems) ensure that even when funding exists, maintenance cannot be performed effectively or efficiently (Ogunbode et al. 2021; Tantoh et al. 2021). These are shown in the table below.

TABLE 21. Cross-Cutting Themes Across Five Countries

Theme	Findings	Nigeria	Ethiopia	DRC	South Africa	Morocco
Build-neglect-rebuild cycle	Donor/government bias toward new construction; maintenance systematically underfunded	Severe	Moderate	Critical	Moderate	Low-Moderate
Institutional fragmentation	Responsibilities split across multiple agencies with poor coordination	Severe (3+ agencies)	Moderate (centralized weak)	Severe (near-absent)	Low-Moderate (clear mandates)	Low-Moderate (coordination gaps)
Corruption and accountability gaps	Diverted maintenance budgets; procurement of poor-quality materials	High	Moderate	Severe (systemic)	Low-Moderate	Low-Moderate
Supply chain failures	Lack of spare parts; reliance on imported components; no local manufacturing	High	High	Critical	Moderate	Moderate
Skills shortages	Few trained technicians; migration of skilled workers; inadequate training programs	High (30-50% vacancies)	Moderate-High (20-40%)	Severe (50-70%)	Moderate (15-25%)	Low-Moderate (10-20%)
Data gaps	Poor asset registers; no condition monitoring; no predictive maintenance	Widespread	Widespread	Complete	Moderate	Moderate

Source: Authors' synthesis based on cross-case analysis

ROOT CAUSE ANALYSIS

The root cause analysis distinguishes three levels of causality immediate, underlying, and systemic that interact to produce and perpetuate infrastructure decay across all five countries. At the immediate level, technical failures directly cause service disruptions: lack of spare parts means broken pumps cannot be repaired; no routine maintenance schedules mean minor issues escalate into major failures; and untrained operators damage equipment through improper use (Nwachukwu et al. 2017; Akinmoladun et al. 2019). These immediate causes are visible and tangible a broken handpump, a leaking pipe, a non-functional treatment plant and consequently receive most of the attention from utilities and donors. However, addressing only immediate causes without tackling underlying and systemic drivers produces short-term relief but does not prevent recurrence, a pattern documented across all five countries where repeated "emergency repairs" fail to restore long-term functionality (Bassey et al. 2020; Olufemi et al. 2020).

At the underlying level, inadequate budgets, weak institutions, and absent asset management systems create the conditions in which immediate failures become inevitable. Maintenance budgets across all five countries range from 2-12% of capital value, far below the 15-20% benchmark, meaning that even well-managed utilities cannot perform required preventative maintenance (Moriarty et al. 2019; Ekpo et al. 2021). Weak institutions fragmented mandates, corruption, high staff vacancies ensure that available budgets are not spent effectively, while absent asset management systems mean no utility has a complete register of its assets, their condition, or their maintenance history (Igbokwe et al. 2022; Kayembe et al. 2018).

At the systemic level, donor bias toward new construction (80-90% of WASH funding for new assets), corruption (systemic in DRC, prevalent in Nigeria, present elsewhere), and low political priority for maintenance (no ribbon-cutting for upkeep) create and sustain the underlying deficits (Nwachukwu et al. 2017; Ait Kadi & Ziyad, 2018). These three levels interact in a self-reinforcing cycle: systemic factors produce underlying deficits, which produce immediate failures, which erode public trust and political will, which reinforce systemic factors. Breaking this cycle requires simultaneous intervention at all three levels not just fixing broken pumps but reforming budgets, strengthening institutions, and changing donor and political incentives. These are shown in the table below.

TABLE 22. Three-Tier Root Cause Framework Across Five Countries

Level	Root Causes	Nigeria	Ethiopia	DRC	South Africa	Morocco
Immediate	Lack of spare parts	High (2-8 weeks)	High (4-12 weeks)	Critical (3-6 months)	Moderate (1-4 weeks)	Moderate (1-3 weeks)
	No routine maintenance schedules	Widespread	Widespread	Complete absence	Partial	Partial (urban)
	Untrained operators	Widespread	Moderate (rural)	Severe	Low-Moderate (rural)	Low-Moderate (rural)
Underlying	Inadequate budgets	5-8% vs. 20-25%	3-6% vs. 15-20%	<2% vs. 15-20%	8-12% vs. 15-20%	6-10% vs. 12-18%
	Weak institutions	Fragmented, corrupt	Centralized weak	Near-absent	Uneven capacity	Coordination gaps
	No asset management systems	Widespread	Widespread	Complete	Moderate	Moderate
Systemic	Donor bias toward new construction	High	High	Critical	Moderate	Moderate
	Corruption	High	Moderate	Systemic	Low-Moderate	Low-Moderate
	Low political priority for maintenance	High	Moderate	High	Moderate	Low-Moderate

Source: Authors' synthesis based on root cause analysis framework

CONSEQUENCES OF DECAY

The consequences of infrastructure decay cascade across service delivery, public health, economic performance, social equity, and sustainable development, creating mutually reinforcing burdens that fall most heavily on vulnerable populations. Service continuity is severely compromised across all five countries, with intermittent supply affecting 70-90% of consumers in Nigeria, Ethiopia, and DRC, and even relatively functional South Africa and Morocco experiencing significant disruptions in rural areas and small towns (Nwachukwu et al. 2020; Olufemi et al. 2020). These service failures directly drive public health outcomes: waterborne diseases including cholera (recurrent in Nigeria, endemic in DRC), typhoid (endemic across Sub-Saharan Africa), and diarrheal disease (killing approximately 200,000 children annually across the four Sub-Saharan countries)

thrive when infrastructure failures force households to rely on contaminated surface water or unprotected wells (Akinmoladun et al. 2019; Kayembe et al. 2018).

The economic consequences are equally severe: replacing failed infrastructure costs 3-5 times more than proper maintenance, non-revenue water losses (20-50% of treated water) waste scarce financial and water resources, and households particularly women and girls spend 2-6 hours daily collecting water during interruptions, sacrificing productive time and education (Moriarty et al. 2019; Ekpo et al. 2021). The equity implications are profound: poor households pay 5-20% of their income for water (compared to 1-3% for wealthy households), rural communities experience 2-3 times higher non-functionality rates than urban areas, and women and girls bear the disproportionate burden of water collection and disease caregiving (Tantoh et al. 2021). Collectively, these consequences directly undermine progress toward Sustainable Development Goal 6 (clean water and sanitation for all), as even where access statistics appear adequate, unreliable service, poor quality, and high costs mean that safe water remains inaccessible to the most vulnerable populations (United Nations, 2020; Lehner et al. 2023).

COMPARISON WITH OTHER AFRICAN COUNTRIES AND THE WORLD

While this study focuses on five diverse African countries, the findings have implications for broader continental and global comparisons that merit brief consideration. North African countries beyond Morocco particularly Egypt, Algeria, and Tunisia face similar challenges of aging infrastructure, aquifer over-extraction, and desalination maintenance, but generally benefit from higher investment levels (2-4% of GDP versus <0.5% in Sub-Saharan Africa), more centralized governance, and greater technical capacity, resulting in lower decay severity despite shared environmental stressors (Olufemi et al. 2020; Ait Kadi & Ziyad, 2018). Other Sub-Saharan nations not examined here including Kenya, Ghana, Tanzania, Uganda, and Mozambique likely exhibit patterns similar to Nigeria and Ethiopia, with high rural non-functionality rates (30-50%), fragmented governance, and severe spare parts supply chain failures, though country-specific studies would be required to confirm these patterns (Tantoh et al. 2021; Mubiala et al. 2022).

At the global level, developing countries in South and Southeast Asia (India, Bangladesh, Indonesia) and Latin America (Peru, Bolivia, rural Brazil) face comparable maintenance challenges, including the "build-neglect-rebuild" cycle, donor bias toward new construction, and urban-rural service disparities (Gleick, 2018; United Nations, 2020). However, higher-income countries including parts of Southern Europe, the United States, and Japan face different maintenance challenges: aging assets (similar to South Africa) but with functional institutions, dedicated maintenance budgets (typically 15-25% of capital value), and advanced asset management systems, meaning decay reflects infrastructure age rather than systemic neglect (Li et al. 2022; Scanlon et al. 2023). A full comparative study across African regions and with other continents is recommended as a separate research endeavor, as the heterogeneity of governance, income, and environmental contexts would require a dedicated multi-continental dataset and analytical framework beyond this review's scope.

LESSONS FROM SUCCESSFUL INTERVENTIONS

Despite the pervasive challenges documented across all five countries, successful interventions at community, national, and regional levels offer transferable lessons for breaking the cycle of decay. Ethiopia's community-based maintenance model, where WASH committees are trained and equipped to manage rural water points with ongoing support from district government and NGOs, has demonstrated that local ownership when combined with technical training, spare parts access, and financial systems for fee collection can reduce non-functionality rates from 40-50% to 15-20% within pilot areas (Tantoh et al. 2021; Nwagboso et al. 2020).

The critical success factor is not decentralization alone but sustained support: committees that receive initial training but no ongoing technical backstopping or spare parts supply almost invariably fail within 12-24 months, as documented in Ethiopia and Nigeria (Bantider et al. 2023; Nwachukwu et al. 2017). South Africa's public-private partnerships for water services particularly in eThekwini (Durban) and other metros demonstrate that private sector participation, when carefully regulated and monitored, can improve maintenance efficiency, reduce non-revenue water, and bring private capital to asset rehabilitation, though these models have proven difficult to scale to smaller municipalities where revenue bases are insufficient to attract private partners (van Koppen & Schreiner, 2014; Adom & Simatele, 2022).

NGO-supported local manufacturing of spare parts in Nigeria offers a promising solution to supply chain failures that plague all five countries. Programs that train local metalworkers to produce handpump components seals, riser pipes, pump cylinders have reduced lead times from months to days in pilot areas, though scaling requires investment in quality control, distribution networks, and protection against import competition (Bassey et al. 2020; Nwachukwu et al. 2017). Finally, asset management systems emerging in South Africa including the Department of Water and Sanitation's regulatory reporting requirements and metros' deployment of GIS-based asset registers and condition monitoring demonstrate that even aging infrastructure can be maintained effectively when utilities have complete asset data, predictive maintenance schedules, and performance-based accountability (Claassen, 2013; Molobela & Sinha, 2011).

Morocco's integration of remote monitoring and SCADA systems for dam operations and urban distribution networks offers another technological model, though the high upfront costs (typically 2 million for city-wide systems) and technical expertise requirements mean such solutions are not immediately transferable to low-income, low-capacity contexts (Khadija et al. 2024; Alaoui, 2013). The common thread across successful interventions is not a single "best practice" but context-appropriate solutions that address multiple causal levels simultaneously: community models require training AND spare parts AND financial systems; PPPs require regulation AND monitoring AND viable revenue bases; technology requires investment AND skills AND maintenance systems of their own.

RECOMMENDATIONS FOR ADDRESSING WATER FACILITIES

The recommendations presented in this study are designed to address the systemic causes of water infrastructure decay and improve the long-term sustainability of water service delivery across African countries. They provide targeted actions for governments, donors, utilities, communities, and NGOs to strengthen maintenance systems, institutional capacity, and infrastructure resilience.

1. Governments should establish legally protected maintenance budgets, strengthen asset management systems, and support decentralized maintenance structures with adequate funding and technical capacity. They must also improve procurement transparency, enforce anti-corruption measures, and promote local spare-parts manufacturing to reduce dependency on imports and improve maintenance efficiency.
2. Development partners should prioritize maintenance and rehabilitation funding alongside new infrastructure development, while requiring credible long-term maintenance plans for project approval. Donors should also invest in technical capacity building and adopt longer funding cycles to ensure infrastructure sustainability beyond the initial construction phase.
3. Utilities need to adopt preventative maintenance systems supported by regular inspections, staff training, and predictive monitoring technologies to reduce infrastructure failures. Strengthening spare-parts inventory management and supplier networks can significantly improve repair response times and operational reliability.
4. Communities and NGOs should strengthen local maintenance committees through technical training, formal organization, and improved access to financial and supply-chain systems. Expanding local fee collection mechanisms and technician training programs can build sustainable community-level maintenance capacity and reduce long-term dependence on external support.

CONCLUSIONS

This study critically reviewed water infrastructure decay and facility maintenance across Nigeria, Ethiopia, Democratic Republic of Congo, South Africa, and Morocco, revealing a systemic crisis driven by predictable patterns of underfunding, institutional fragmentation, and perverse political incentives rather than isolated technical failures.

SUMMARY OF FINDINGS

Water infrastructure decay is severe across Nigeria, Ethiopia, DRC, and South Africa, with Morocco exhibiting moderate but persistent decay concentrated in rural areas and secondary networks. Maintenance failure is systemic, not accidental, reflecting predictable patterns of underfunding, institutional fragmentation, and perverse political incentives rather than isolated technical problems. Root causes span technical (aging, corrosion, spare parts), financial (budget deficits, donor bias), institutional (fragmentation, corruption, skills shortages), and political (ribbon-cutting over upkeep, low tariffs) domains. The consequences of decay intermittent supply, waterborne diseases, high lifecycle costs, and disproportionate burdens on poor and rural communities directly undermine water access, public health, and progress toward Sustainable Development Goal 6.

KEY CONTRIBUTIONS

This study provides the first critical review focused specifically on infrastructure decay and maintenance failures across multiple African countries, moving beyond governance or technology frameworks to center the neglected dimension of asset management. The root cause analysis framework distinguishes immediate, underlying, and systemic causes of decay, enabling interventions that address structural drivers rather than just symptoms.

The comparative assessment of five diverse nations: Nigeria, Ethiopia, DRC, South Africa, and Morocco reveals patterns that single-country studies cannot detect, including the gradient of decay severity correlated with governance coherence. Actionable recommendations tailored to governments, donors, utilities, communities, and NGOs offer a multi-stakeholder roadmap for breaking the build-neglect-rebuild cycle and shifting toward maintenance-first water infrastructure policy.

LIMITATIONS

This study relied on secondary data only, no primary field data collection. Quantitative data availability varies significantly, with DRC showing the most severe gaps. Exclusion of other African and additional Sub-Saharan nations limits continent-wide generalization.

FUTURE RESEARCH DIRECTIONS

1. Field-based asset condition assessments using standardized methodologies (e.g., Infrastructure Leakage Index, asset deterioration curves) are urgently needed to generate primary data on decay severity, particularly in data-scarce countries like DRC and rural areas of Nigeria and Ethiopia.
2. Cost-benefit analysis comparing maintenance-first versus rebuild-after-failure approaches across different infrastructure types and contexts would provide economic evidence to counter the prevailing political economy bias toward new construction.
3. A comparative study explicitly including North African countries (Egypt, Algeria, Tunisia) alongside Sub-Saharan nations would enable continent-wide generalization and identification of region-specific decay drivers.
4. Longitudinal studies tracking maintenance interventions over 5-10 years are needed to determine which models community-based, PPP, utility-led produce sustained functionality rather than short-term improvements.
5. Finally, research on the role of remote sensing (satellite imagery for leakage detection), Internet of Things (smart meters, pressure sensors), and mobile applications (citizen reporting of failures) in infrastructure monitoring could identify cost-effective technological solutions appropriate for low-capacity, low-resource contexts.

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DECLARATION OF COMPETING INTEREST

None.

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