Drinking from a Shrinking Cup: Groundwater Depletion, Urban Flooding, and the Hidden Water Crisis Beneath Lagos, Nigeria

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ABSTRACT

Lagos, Nigeria, is experiencing a significant water crisis characterised by urban flooding, groundwater depletion, declining water quality, and saltwater intrusion. This article examines the interconnected issues of groundwater depletion, urban flooding, and climate change, advocating for the integration of groundwater management into the city's climate adaptation strategies. The objectives include: (i) assessing the state of Lagos's groundwater resources amid urbanisation and climate change; (ii) demonstrating the link between seasonal flooding and groundwater contamination; and (iii) proposing solutions like Managed Aquifer Recharge and integrated flood-water governance. The study synthesises peer-reviewed literature and institutional reports from 2012 to 2026, highlighting that urban development has decreased aquifer recharge and that flooding, instead of replenishing groundwater, contaminates it. Climate change further exacerbates these challenges through rising sea levels and changing rainfall patterns. The findings suggest that groundwater depletion and flooding are part of a reinforcing feedback loop, emphasising the need for integrated urban water management strategies to mitigate flood risks and improve long-term water security in Lagos.

INTRODUCTION: THE CITY THAT FLOODS AND THIRSTS

Every rainy season, Lagos confronts significant flooding challenges. Low-lying districts such as Oshodi, Ajegunle, and Ikorodu are among the areas worst affected, with roads submerged and households routinely displaced for the duration of the rains. Despite receiving over 1,400 millimetres of rainfall annually, Lagos appears to struggle with managing its water resources effectively. Simultaneously, beneath the surface, Lagos faces a critical water scarcity issue. Millions of residents rely on boreholes and hand-dug wells for their daily water supply. The public pipe network, operated by the Lagos State Water Corporation, serves only a small fraction of the city's estimated population of 20 million (Balogun et al., 2017; Olabode & Comte, 2024). For the remainder, ground sources represent the primary water supply. However, these sources are increasingly becoming inadequate. Boreholes in coastal communities from Victoria Island to Ajah are frequently abandoned after yielding salty water, rendering it unsuitable for consumption. This situation arises from a combination of over-extraction and encroaching sea levels, which threaten the freshwater aquifers beneath Lagos (Babatunde, 2012; Ajani et al., 2021). This scenario is not merely a matter of deficient rainfall. It illustrates the repercussions of a rapidly expanding urban area extracting groundwater faster than natural replenishment occurs. Concrete infrastructure has replaced the soil that previously allowed rainwater to filter into aquifers. Concurrently, climate change is subtly altering the conditions that once ensured the reliability of groundwater. The situation exemplifies two intertwined crises: flooding above and depletion below, both stemming from common causes and requiring immediate attention.

Between 2000 and 2019, the built-up area of Lagos expanded from 807 to 1,183 square kilometres, a remarkable 50 per cent increase in less than two decades (Olabode & Comte, 2024). Every new road, rooftop, and paved surface has decreased the permeable land that previously facilitated rainwater recharge into underground aquifers. The same impermeable surfaces that now direct floodwaters into overwhelmed drainage systems once allowed rainfall to percolate into the earth and replenish the water table. Urbanisation has not only intensified flood risks but has also precipitated a groundwater shortage obscured by periods of rainfall. The consequences of these developments exacerbate each other. Floodwaters in Lagos typically lack cleanliness. Water quality assessments of hand-dug wells have indicated that levels of chloride, nitrate, sulfate, electrical conductivity, total dissolved solids, chromium, and cadmium exceed WHO permissible limits. These conditions are linked to saltwater intrusion, wastewater discharge, and oil leakage from compromised pipelines throughout regions such as Victoria Island, Eti Osa, Ajah, and Lagos Island (Olabode & Comte, 2024; Oyeyemi et al., 2015). Consequently, floods fail to recharge the aquifer and instead contaminate it. Communities already struggling with unreliable water access find their last remaining resources tainted in the same week their homes are inundated.

Climate change serves as an accelerant in this crisis. The global hydrological cycle is increasingly influenced by climate change, with effects expected to intensify over time as a result of rapid population growth, alterations in land use, and rising temperatures across West Africa (Bulkeley & Newell, 2023; Tramblay et al., 2024). Rising sea levels push saltwater further inland along Lagos's expansive coastline. The urgent demand for water has led to accelerated borehole drilling, resulting in severe water shortages due to over-extraction, alongside compounding issues of saline intrusion, wastewater discharge, and contamination of coastal aquifer systems (Akoteyon et al., 2018; Tijani et al., 2020). Additionally, land subsidence attributable to the excessive extraction intended to mitigate surface water shortfalls renders the city more prone to flooding. This cyclical relationship deepens each crisis, while traditional approaches to water management and flood response, viewed as distinct policy areas, fail to address the intertwined nature of these challenges. Seawater intrusion poses an escalating threat to Lagos's coastal aquifers, a situation exacerbated by rapid urban development, industrial waste discharge, and the overexploitation of groundwater resources (Oloruntola et al., 2026). Nonetheless, this critical emergency remains largely unnoticed in national adaptation plans and is absent from mainstream climate discussions, far less prominent than the flooding that captures public attention each rainy season.

This analysis posits that the groundwater crisis in Lagos represents a climate emergency that unfolds discreetly beneath a city preoccupied with immediate flood responses rather than addressing its declining water resources. Understanding these dual crises as an interconnected system is not merely an academic exercise but a prerequisite for developing effective solutions.

PROBLEM STATEMENT

For the millions of Lagos residents in areas such as Oshodi, Ajegunle, and Ajah who have no pipe network and no alternative to the borehole in their compound, losing groundwater is not a policy abstraction; it is the loss of their only water source. Yet this crisis, driven by the same rapid urbanisation and climate change that floods their streets every rainy season, remains largely absent from the adaptation plans and governance frameworks intended to protect them.

The core problem is this: Lagos is losing its groundwater, climate change is accelerating that loss, and neither crisis is being solved because both are being treated separately. Climate change amplifies the emergency through rising sea levels pushing saltwater further inland, shifting rainfall patterns reducing recharge reliability, and rising temperatures increasing demand on an already stressed resource. The consequence is a water crisis hiding inside a flood crisis, and until groundwater depletion is recognised as a frontline climate issue in Nigerian adaptation policy and public discourse, Lagos cannot build the resilience its people urgently need (Babatunde, 2012; Bulkeley & Newell, 2023).

BACKGROUND OF STUDY

Water is the defining resource challenge of the 21st century, and nowhere is this more acutely visible than in

Africa's rapidly urbanising coastal cities. Lagos, with a population exceeding 20 million and growing at approximately 600,000 residents per year, sits at the intersection of multiple converging water crises: too much water during the rainy season, and critically too little safe water year-round (Olabode & Comte, 2024).

Groundwater has historically served as the backbone of water supply across sub-Saharan Africa, providing drinking water, supporting smallholder agriculture, and buffering communities against surface water variability (MacDonald et al., 2021). In Lagos specifically, where the public pipe network supplied by the Lagos State Water Corporation meets only a fraction of daily demand, boreholes and hand-dug wells are not supplementary infrastructure; they are primary survival infrastructure for millions of low- and middle-income residents.

Yet this resource is under unprecedented stress. Globally, groundwater is declining across nearly 1,700 monitored aquifers, often at accelerating rates, with climate change disrupting recharge cycles and amplifying extraction demands (Jasechko et al., 2024). In West Africa, climate and land use change are significantly influencing hydrological processes, including infiltration, surface runoff, and groundwater flow, with population growth and urbanisation projected to intensify these pressures dramatically through 2050 (Tramblay et al., 2024).

Lagos presents a particularly acute case. Between 2000 and 2019, the city's built-up surface expanded by 50 per cent, from 807 to 1,183 square kilometres, driven by industrialisation and population growth (Olabode & Comte, 2024). This expansion has progressively sealed the permeable surfaces through which rainfall once recharged shallow aquifers, while simultaneously increasing the number of boreholes drawing from those same depleting reserves. The result is a compounding deficit: less water entering the ground, more being taken out.

The consequences have been well documented in the hydrogeological literature but remain largely absent from public climate discourse. Saltwater intrusion is advancing into coastal aquifers across Lagos Island, Victoria Island, Ajah, Apapa, and Ajegunle, with multiple studies recording chloride, nitrate, and total dissolved solids exceeding WHO permissible limits in hand-dug wells serving densely populated communities (Babatunde, 2012; Oloruntola et al., 2026). Several boreholes in these areas have been decommissioned and abandoned following rapid salinisation after drilling (Ajani et al., 2021).

Compounding this is the role of flooding, Lagos's most visible climate hazard, in accelerating groundwater contamination. When seasonal floods inundate low-lying communities, they carry sewage, industrial effluent, and oil from vandalised pipelines directly into shallow aquifer systems, degrading water quality precisely when demand for alternative sources is highest. Far from alleviating groundwater stress, flooding in Lagos exacerbates it.

Despite the severity and breadth of this evidence, groundwater depletion has not achieved the policy visibility of flooding or heat in Lagos's urban climate agenda. It does not generate the same emergency response, the same media coverage, or the same allocation of adaptation finance. This article seeks to address that gap, situating Lagos's groundwater crisis within the broader climate science literature, demonstrating its linkage to the city's flooding emergency, and making the case for integrated policy solutions that treat both crises as one, as illustrated in the study area map below (Figure 1).

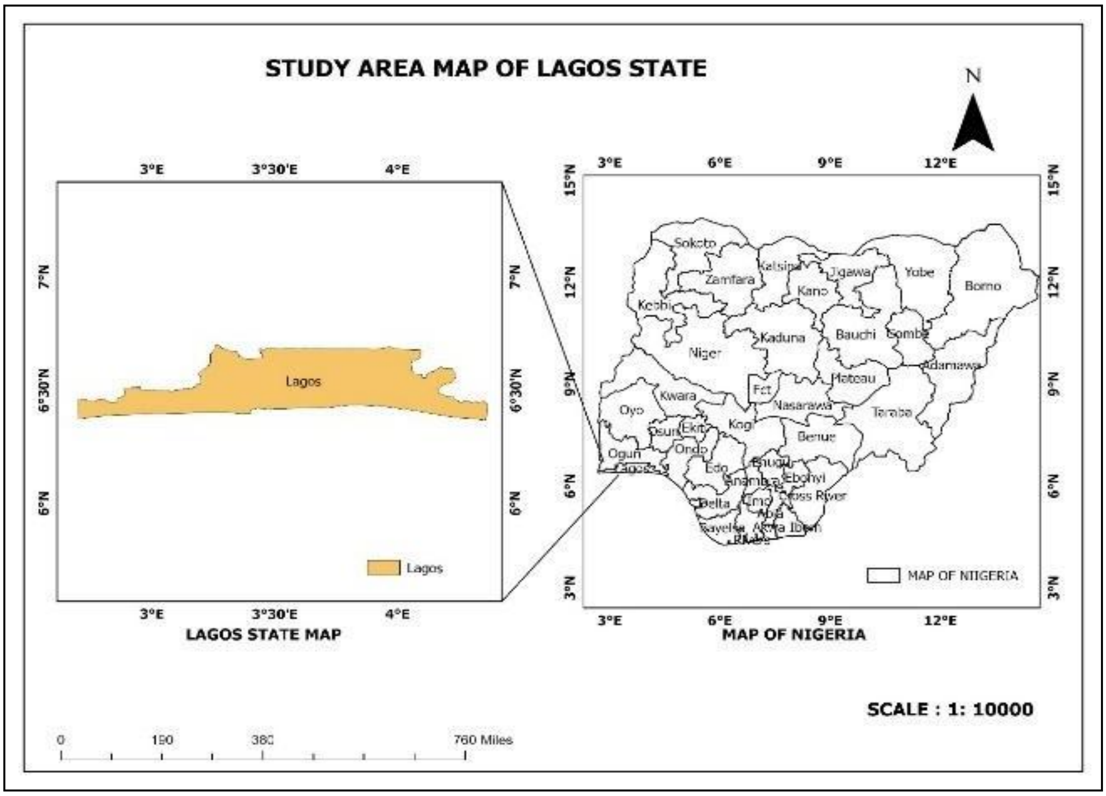

Figure 1: Study Area Map

AIM AND OBJECTIVES AIM

This article aims to examine the relationship between groundwater depletion, urban flooding, and climate change in Lagos, Nigeria, and to advocate for the integration of groundwater management into the city's climate adaptation framework.

Objectives

The specific objectives of this article are to:

1. Evaluate the current status of groundwater resources in Lagos, focusing on how rapid urbanisation and climate change contribute to aquifer depletion and saltwater intrusion affecting coastal communities.

2. Establish the mechanistic connection between seasonal flooding and groundwater contamination, illustrating how Lagos's two most pressing water challenges are manifestations of a single, interconnected crisis.

3. Identify evidence-based solutions, particularly Managed Aquifer Recharge and integrated flood water governance frameworks, that provide simultaneous remedies for both groundwater depletion and urban flooding in the Lagos megacity.

LITERATURE REVIEW

Global Groundwater Depletion and Climate Change

Groundwater represents the world's largest accessible freshwater reserve, supplying drinking water to approximately two billion people and supporting nearly half of all irrigated agriculture globally. Yet this resource is under accelerating stress. The largest global assessment of groundwater levels to date, spanning nearly 1,700 aquifers, confirmed that groundwater is rapidly declining across the globe, often at accelerating rates, driven by intensifying extraction demands and climate-driven disruptions to natural recharge cycles (Jasechko et al., 2024). Climate change hastens the global hydrological cycle, altering precipitation patterns, increasing evapotranspiration, and reducing the frequency and reliability of the rainfall events that replenish aquifers (Bulkeley & Newell, 2023). The consequences extend beyond water scarcity; groundwater depletion drives land subsidence, accelerates saltwater intrusion in coastal zones, threatens agricultural productivity, and undermines ecosystem integrity across multiple biomes.

Groundwater in Sub-Saharan Africa

In sub-Saharan Africa, groundwater plays a disproportionately important role in sustaining livelihoods. With one in three people lacking access to safe water across the region, groundwater provides most domestic water supply in rural areas and supports poverty reduction through smallholder irrigation (MacDonald et al., 2021). Research published in Nature by a consortium of 32 scientists confirmed that groundwater replenishment in sub-Saharan Africa depends heavily on intense rainfall and flood events, meaning that while shallow aquifers show resilience to short-term climate variability, long-term shifts in rainfall intensity and land cover pose significant recharge risks (Cuthbert et al., 2019). Mean groundwater residence times in shallow West African aquifers range from 20 to 70 years, meaning that depletion occurring today reflects extraction decisions made decades ago, and the consequences of current over-abstraction will be felt well into the second half of this century (MacDonald et al., 2021).

West Africa: Urbanisation, Land Use, and Hydrological Disruption

Across West Africa, climate and land use change are significantly influencing hydrological processes including evapotranspiration, infiltration, surface runoff, groundwater flow, and stream discharge (Tramblay et al., 2024). The future of water supply in the region will be shaped by strong external forces: rapid population growth, rising temperatures averaging between 25.9 and 34°C annually, and dramatic land cover transformation (Adeyeri & Ishola, 2021). Urban expansion is the dominant land use driver, progressively replacing vegetated and permeable surfaces with impervious built-up areas that intercept rainfall before it can recharge underground aquifers. This dynamic creates a self reinforcing cycle: growing urban populations increase groundwater extraction while simultaneously reducing the natural processes that would replenish what is taken.

Lagos: A Megacity Under Hydrogeological Stress

Lagos presents the most acute expression of these regional trends. The city's built-up area expanded from 807 to 1,183 square kilometres between 2000 and 2019, a 50 per cent increase driven by industrialisation, population growth, and unplanned urban sprawl (Olabode & Comte, 2024). This rapid expansion has been accompanied by intensive borehole drilling across residential, commercial, and industrial areas to compensate for the inadequate reach of the public pipe network. The Lagos State Water Corporation currently supplies far below the city's estimated daily water demand: as of 2010, the three major waterworks and the network of mini/micro waterworks together produced approximately 1 million cubic metres per day (0.54 million from major works, 0.41 million from mini/micro works) against an estimated demand of 2.4 million cubic metres per day, leaving a daily production gap of roughly 1.5 million cubic metres (LWC, 2010, via Olabode & Comte, 2024). This leaves the majority of residents dependent on private groundwater extraction with minimal regulatory oversight.

The hydrogeological consequences are well documented. Evidence of aquifer depletion, saltwater intrusion, and groundwater contamination attributed to over-abstraction and anthropogenic pollution has been recorded across multiple Lagos communities (Akoteyon et al., 2018; Tijani et al., 2020). Water quality assessments of hand dug wells across Lagos coastal areas found mean values of chloride, nitrate, sulphate, electrical conductivity, total dissolved solids, chromium, and cadmium exceeding WHO and Nigerian Standard for Drinking Water Quality permissible limits conditions associated with saltwater intrusion, wastewater discharge, and oil leakage from

vandalised pipelines in Victoria Island, Eti Osa, Ajah, and Lagos Island (Babatunde, 2012; Olabode & Comte, 2024). In Apapa Ajegunle, a 2026 geophysical assessment combining Vertical Electrical Sounding and Electrical Resistivity Tomography confirmed that seawater intrusion is fast becoming an increasing threat to coastal aquifers, with saltwater intrusion resulting in several boreholes being decommissioned and abandoned (Oloruntola et al., 2026).

Flooding, Contamination, and the Compounding Crisis

The literature on Lagos flooding is extensive, documenting the city's chronic vulnerability to seasonal inundation driven by inadequate drainage infrastructure, low-lying coastal topography, and intensifying rainfall events associated with climate change. However, the specific interaction between flood events and groundwater quality has received comparatively limited scholarly attention. Existing studies confirm that undocumented and uncontrolled stormwater and wastewater discharge from industrial activities are responsible for surface water and groundwater pollution across multiple Lagos locations (Olabode & Comte, 2024). Land subsidence resulting from groundwater over-extraction further lowers surface elevation, increasing flood exposure and the duration of inundation in already vulnerable communities. Satellite-based evidence corroborates this mechanism directly: a study integrating Sentinel 1 InSAR displacement data with GRACE derived groundwater head changes across Lagos (2015–2019) found ground settlement concentrated along the lagoon margins, in low lying alluvial areas, in reclaimed peatland, and along the Atlantic coastline, with five critical settlement points identified at Ikoyi, Ketu Alapere, Orile Iganmu, Ijora, and Okota, and a maximum settlement standard deviation of 102mm (Ikuemonisan et al., 2021). The literature therefore points toward a bidirectional relationship: groundwater depletion worsens flooding, and flooding worsens groundwater quality, but this relationship has not been synthesised into a unified analytical or policy framework.

Managed Aquifer Recharge as an Integrated Solution

Managed Aquifer Recharge has emerged in the literature as a promising framework for simultaneously addressing groundwater depletion and urban stormwater management. Olabode and Comte (2024) identified that excess stormwater runoff in Lagos, currently a primary driver of flooding, could instead be captured and used for MAR to directly replenish groundwater resources and mitigate aquifer depletion, saltwater intrusion, and land subsidence. The study identified multiple MAR techniques applicable across different Lagos hydrogeological zones, including infiltration basins and shallow wells in northern expanding built-up areas, and aquifer storage and recovery schemes in coastal zones. The volume of stormwater currently discharged as a flood hazard is more than double the volume needed to meaningfully address groundwater deficits, representing an enormous untapped resource whose capture would serve dual climate adaptation purposes.

Table 2 summarises the individual studies underpinning the Lagos-specific evidence reviewed above, alongside the limitations noted for each in the text.

Study	Location	Groundwater Indicators	Contamination Parameters	Findings	Limitations
Olabode & Comte (2024)	Lagos, citywide	Built-up area expansion (807 → 1,183 km², 2000–2019); water production–demand gap (~1.5M m³/day); excess wet-season stormwater (>2× MAR requirement)	Cited jointly with Babatunde (2012) for chloride, nitrate, sulphate, EC, TDS, chromium and cadmium exceedances in Victoria Island, Eti-Osa, Ajah and Lagos Island	Identifies Managed Aquifer Recharge (MAR) as a route to capture excess stormwater and replenish depleted aquifers, counter saltwater intrusion and reduce subsidence	Stormwater-volume figure is drawn from a single study; corroborating research would strengthen confidence in the scale of the MAR opportunity
Akoteyon et al. (2018)	Multiple Lagos communities	Aquifer depletion and over-abstraction linked to a compounding urban water	Cited jointly with Tijani et al. (2020) for groundwater contamination	Documents aquifer depletion, saltwater intrusion and contamination recorded across	Not individually detailed beyond joint citation with Tijani et al.; part of the

		deficit	from over-abstraction and anthropogenic pollution	multiple communities	geographically uneven evidence base flagged in Section 7.7
Tijani et al. (2020)	Lagos (communities not individually specified in text)	Groundwater geochemistry	Cited jointly with Akoteyon et al. (2018) for contamination attributed to over-abstraction and pollution	Corroborates hydrogeochemical evidence of depletion and contamination	Cited only jointly with Akoteyon et al.; no standalone findings detailed in the text
Babatunde (2012)	Victoria Island, Eti-Osa, Ajah, Lagos Island (hand-dug wells)	Not a focus of this study	Chloride, nitrate, sulphate, EC, TDS, chromium and cadmium exceeding WHO/NSDWQ limits; dissolved oxygen below acceptable levels	Earliest evidence in the review of saltwater intrusion, wastewater discharge and pipeline-oil contamination reaching hand-dug wells	Oldest study in the review (2012); predates the 2000–2019 land-use change data discussed alongside it
Ajani et al. (2021)	Lagos coastal waters and sediments	Borehole decommissioning following rapid salinisation after drilling	Pollution status of coastal waters and sediments	Documents boreholes abandoned after drilling due to rapid salinisation	Not elaborated further in the text beyond this finding
Oloruntola et al. (2026)	Apapa-Ajegunle	Resistivity range 1.0–50,022 Ωm across four to five subsurface layers (VES/ERT survey)	Saline intrusion confirmed via geophysical resistivity contrast	Confirms active seawater intrusion into the shallow coastal aquifer; several boreholes decommissioned and abandoned	Single-site study (Apapa-Ajegunle only); part of the coastal/island bias in the evidence base noted in Section 7.7
Ikuemonisan et al. (2021)	Ikoyi, Ketu-Alapere, Orile-Iganmu, Ijora, Okota	Land subsidence: maximum settlement deviation of 102 mm; five critical settlement points identified	Not a focus of this study	Sentinel-1 InSAR combined with GRACE groundwater-head data (2015–2019) links groundwater depletion to measurable land subsidence	Monitoring period limited to 2015–2019 (four years); findings confined to five specific settlement points

Table 2. Summary of key Lagos-specific studies reviewed, including locations, indicators, contamination parameters, principal findings, and limitations as described in the text.

RESEARCH GAP

Lagos faces significant challenges with flooding and groundwater depletion, yet these issues are often treated separately. Research typically addresses aquifer depletion, saltwater intrusion, and urban flooding in isolation, leading to disconnected solutions like flood drainage and borehole regulation. Groundwater depletion, a critical water security threat in Lagos, is notably missing from Nigeria's climate adaptation plans. Low-income communities in informal settlements, who depend on borehole water, lack representation in policy discussions. This article seeks to highlight the interconnectedness of the groundwater crisis and flooding, advocating for an integrated response to address both issues effectively.

MATERIALS AND METHODS

Research Design

This article adopts a narrative literature review approach, synthesising peer-reviewed hydrogeological studies, climate science reports, urban planning literature, and water quality assessments to construct an integrated analysis of groundwater depletion and urban flooding in Lagos, Nigeria. As a science communication article targeting a general audience, primary data collection was not conducted. Instead, the study draws on the existing body of published evidence to develop a unified analytical framework and policy argument.

Data Sources

Literature was sourced from peer-reviewed journals including WIREs Water, Nature, Scientific Reports, Hydrology and Earth System Sciences, and Science of the Total Environment, as well as institutional reports from the British Geological Survey, the International Water Management Institute, and the Global Environment Facility. Search terms used included "groundwater depletion Lagos," "saltwater intrusion Nigeria," "urban flooding Lagos," "managed aquifer recharge West Africa," and "climate change groundwater Africa." Studies published between 2012 and 2026 were prioritised to ensure currency, with foundational earlier works included where essential for contextual grounding.

Inclusion Criteria

Studies were selected based on three criteria:

1. Direct relevance to groundwater resources, water quality, or urban hydrology in Lagos or West Africa broadly.

2. Explicit engagement with climate change as a driver of hydrological stress or urban water insecurity.

3. Availability of quantitative data on aquifer conditions, water quality parameters, land use change, or flood-groundwater interactions applicable to the Lagos context.

Search Strategy and Screening Process

Searches were conducted across Scopus, Web of Science, Google Scholar, and institutional repositories (British Geological Survey, International Water Management Institute, Global Environment Facility) using the search strings listed in 7.2, combined with Boolean operators (e.g., "groundwater depletion" AND "Lagos"; "urban flooding" AND "Nigeria" AND "climate change"). Searches were limited to English language sources published between 2012 and 2026. An initial pool of records was identified across these databases. After removing duplicates, titles and abstracts were screened for relevance. Full texts were then assessed against the inclusion criteria in 7.3, with studies excluded for insufficient relevance to Lagos or West African hydrogeology, lack of quantitative data, or absence of a clear climate change linkage. Studies meeting all inclusion criteria were retained for thematic synthesis, supplemented by institutional and grey literature reports where peer-reviewed data were unavailable for a specific parameter (e.g., current borehole density).

Quality Assessment Criteria

Included studies were assessed against three quality indicators: (1) publication in a peer-reviewed journal or issuance by a recognised research institution; (2) transparent methodology, including a stated sampling method, geophysical technique, or modelling approach; and (3) direct empirical grounding in Lagos or a comparable West African coastal hydrogeological context. Studies relying solely on secondary or anecdotal sources without empirical data were excluded from the evidentiary core of the review and cited, where relevant, only for contextual or policy framing.

Analytical Framework

Selected literature was analysed thematically across four dimensions: the state of groundwater resources in Lagos; the role of urbanisation and climate change as compounding drivers of depletion; the interaction between flooding and groundwater contamination; and the evidence base for integrated remediation strategies including Managed Aquifer Recharge. Findings from individual studies were synthesised across these themes rather than reported in isolation, enabling the construction of a unified narrative that connects hydrogeological evidence to climate adaptation policy.

LIMITATIONS

As a review-based article, the findings are bounded by the scope and quality of existing published literature. Primary hydrogeological data, including real-time aquifer monitoring, borehole water level measurements, and direct flood groundwater interaction sampling across Lagos communities, were not independently collected. Furthermore, the Lagos groundwater literature, while growing, remains geographically uneven, with coastal and island communities better represented than peri-urban and mainland areas. These gaps are acknowledged where relevant in the discussion and identified as priorities for future primary research.

RESULTS AND DISCUSSION

Table 1 summarises the principal quantitative findings drawn from the reviewed literature, brought together here to make explicit the scale of change across the groundwater, land use, and climate indicators discussed individually in the sections that follow.

Indicator	Value	Period / Location	Source
Built-up area expansion	807 → 1,183 km² (+50%)	Lagos, 2000–2019	Olabode & Comte, 2024
Vegetated surface loss	3,650 → 3,330 km² (−9%)	Lagos, 2000–2019	Olabode & Comte, 2024
Water body area loss	982 → 926 km² (−6%)	Lagos, 2000–2019	Olabode & Comte, 2024
Monitored aquifers in global decline	~1,700 assessed; 71% declining	Global	Jasechko et al., 2024
Regional temperature range	25.9–34°C (rising)	West Africa	Tramblay et al., 2024
Excess storm water vs. MAR need	>2× required volume	Lagos, wet season	Olabode & Comte, 2024
Resistivity range (saline intrusion)	1.0–50,022 Ωm	Apapa Ajegunle	Oloruntola et al., 2026
City area	3,577 km²	Lagos	Healy et al., 2020, via Olabode & Comte, 2024
Population growth rate	3.5% per annum	Lagos, current	Olabode & Comte, 2024
Peak annual rainfall	2,234 mm (1989); 2,117 mm (2014); 2,097 mm (2019)	Lagos, 1980–2020	NIMET, 2020, via Olabode & Comte, 2024

Projected sea-level rise	80 cm	Lagos, by century end	Olabode & Comte, 2024
Water production (major works)	0.54 million m³/day	Lagos, 2010	LWC, 2010, via Olabode & Comte, 2024
Water production (mini/micro works)	0.41 million m³/day	Lagos, 2010	LWC, 2010, via Olabode & Comte, 2024
Total water demand	2.4 million m³/day	Lagos, 2010	LWC, 2010, via Olabode & Comte, 2024
Water supply gap	~1.5 million m³/day	Lagos, 2010	LWC, 2010, via Olabode & Comte, 2024
Land subsidence settlement variability	Maximum standard deviation: 102 mm	Ikoyi, Ketu Alapere, Orile Iganmu, Ijora, Okota	Ikuemonisan et al., 2021
InSAR/GRACE monitoring period	2015–2019	Lagos	Ikuemonisan et al., 2021

Table 1. Summary of key quantitative findings from the reviewed literature. Figures are drawn from single studies unless otherwise noted; corroborating data would strengthen confidence, particularly for the MAR volume estimate.

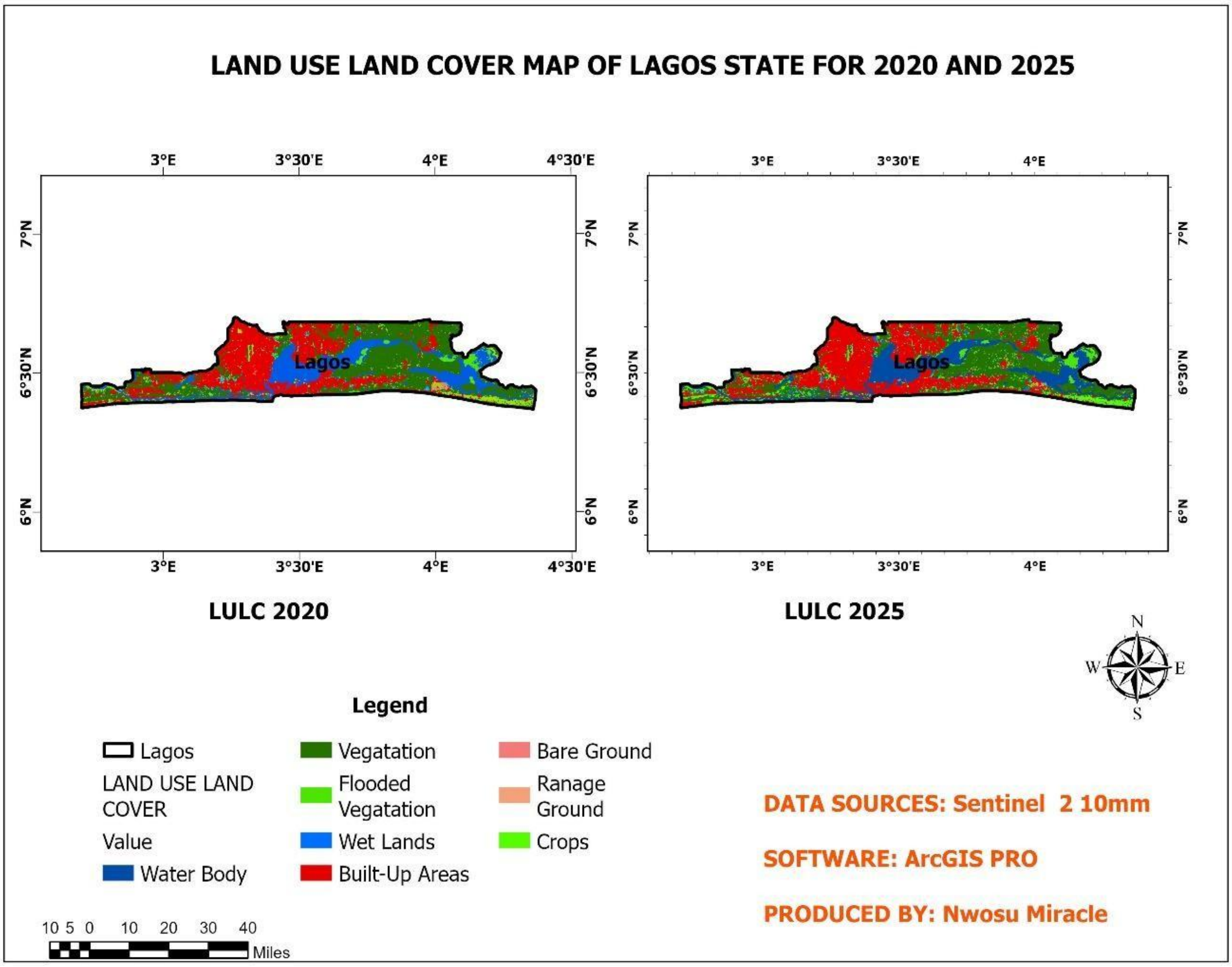

Figure 2: Land use land Cover Map of Lagos

The State of Groundwater in Lagos: A Resource Under Siege

The evidence drawn from hydrogeological studies conducted across Lagos between 2012 and 2026 paints a consistent and troubling picture: the groundwater that millions of Lagos residents depend on is declining in both quantity and quality, and the pace of that decline is accelerating.

The most visible symptom is saltwater intrusion. Across Lagos Island, Victoria Island, Ajah, Oworo, and Apapa Ajegunle communities where the majority of residents have no access to piped water, boreholes are increasingly being abandoned after producing water that is unsafe to drink. Geophysical surveys in Apapa Ajegunle identified between four and five distinct subsurface layers with resistivity values ranging from 1.0 to 50,022 Ωm, confirming active saline intrusion advancing into the shallow coastal aquifer system beneath one of Lagos's most densely populated communities (Oloruntola et al., 2026). Wells designated AA, CMS, OBA, and VIL recorded electrical conductivity readings consistent with significant saline water intrusion, rendering them unsuitable for drinking or domestic use (Oyeyemi et al., 2024).

Water quality assessments of hand-dug wells across Lagos coastal areas found that mean values of chloride, nitrate, sulphate, electrical conductivity, total dissolved solids, chromium, and cadmium all exceeded WHO and Nigerian Standard for Drinking Water Quality permissible limits, while dissolved oxygen concentrations fell below the lower bound of acceptable levels (Babatunde, 2012; Olabode & Comte, 2024). These are not marginal exceedances. They represent water that is actively harmful to the people drinking it, and in communities like Ajah, Ajegunle, and Lagos Island, these communities have few, if any, documented alternative water sources.

These exceedances translate directly into household-level risk, leaving residents to weigh continued use of contaminated wells against the cost and availability of alternatives.

Urbanisation as the Primary Driver

The data on land use change in Lagos provides the structural explanation for why groundwater is failing. Between 2000 and 2019, Lagos's built-up area expanded from 807 to 1,183 square kilometres, a 50 per cent increase in less than two decades (Olabode & Comte, 2024). Over the same period, vegetated surfaces decreased by 9 per cent, from 3,650 to 3,330 square kilometres, and water bodies shrank by 6 per cent, from 982 to 926 square kilometres.

These figures tell a hydrogeological story with serious consequences. Vegetation and permeable soil are the primary mechanisms through which rainfall infiltrates the ground and recharges aquifers. Every hectare of vegetation cleared and sealed under concrete or asphalt is a hectare that no longer contributes to the underground water table. As Lagos has expanded outward, swallowing farmland, wetlands, and mangrove edges in its growth, it has progressively dismantled its own natural water replenishment infrastructure.

At the same time, the growing population that drives urban expansion also drives growing demand for groundwater. With the Lagos State Water Corporation meeting only a fraction of the city's daily water needs, residents and businesses have responded by drilling more boreholes, extracting more water from aquifers that are receiving less recharge. The result is a compounding deficit that worsens with every new building, every new road, and every new resident arriving in a city already outpacing its own water supply (Akoteyon et al., 2018).

This dynamic is not unique to Lagos. Across West Africa, climate and land use change are significantly influencing hydrological processes including infiltration, surface runoff, and groundwater flow, with rapid population growth projected to intensify these pressures dramatically through 2050 (Tramblay et al., 2024). But in Lagos, a coastal megacity growing at 600,000 residents per year on low-lying terrain already vulnerable to sea-level rise, the consequences are uniquely severe.

Flooding as a Compounding Factor: When Too Much Water Makes Things Worse

A counterintuitive finding to emerge from the literature is that Lagos's chronic flooding problem does not relieve its groundwater crisis; it worsens it.

When seasonal rains overwhelm Lagos's inadequate drainage infrastructure and floodwaters inundate low-lying communities, the water that enters the ground is not clean. It carries sewage from overwhelmed sanitation systems, industrial effluent from unregulated discharge points, and oil from vandalised crude pipelines, all of which infiltrate shallow aquifers and degrade water quality precisely when demand for alternative water sources is at its highest (Olabode & Comte, 2024).

The relationship runs in both directions. Groundwater over-extraction causes land subsidence, the gradual sinking of the ground surface as the underground support provided by water-filled aquifer pores is removed. In a coastal city like Lagos, even marginal subsidence lowers the elevation of communities relative to sea level and drainage channels, increasing their exposure to flooding and prolonging inundation after each rain event. Communities that drill the deepest to find water are, in doing so, making themselves more vulnerable to the floods that contaminate it.

This bidirectional feedback depletion worsening floods, floods worsening depletion is the defining characteristic of Lagos's water crisis, and it is precisely what makes treating flooding and groundwater as separate policy problems inadequate. While no single study has tracked this feedback loop within one household, the pattern documented across multiple Lagos sites suggests it plays out at the individual level: a household in Ajah whose borehole now yields brackish water and whose compound floods each rainy season is not experiencing two separate problems, but a single compounding one.

Climate Change as the Accelerant

Urbanisation and over-extraction alone would be sufficient to constitute a serious water crisis in Lagos. Climate change transforms it into an accelerating emergency.

Globally, groundwater is declining across nearly 1,700 monitored aquifers at accelerating rates, with climate change disrupting recharge cycles and amplifying extraction demands (Jasechko et al., 2024). In West Africa specifically, annual average temperatures ranging between 25.9 and 34°C are projected to rise further, increasing evapotranspiration rates and water demand while shifting the rainfall patterns that govern aquifer recharge (Tramblay et al., 2024). Rising sea levels driven by global warming push saltwater further inland along Lagos's extensive coastline, expanding the zone of saline intrusion into freshwater aquifers beyond what over-extraction alone would produce.

There is also a temporal dimension that deserves greater public attention. Mean groundwater residence times in shallow West African aquifers range from 20 to 70 years, meaning that the water being extracted today entered the ground between the 1950s and the early 2000s (MacDonald et al., 2021). The depletion happening now reflects decades of accumulated decisions. And the consequences of the extraction happening today will be felt by the next generation of Lagos residents long after the boreholes that caused the damage have been forgotten.

The Solution That Connects Both Crises: Managed Aquifer Recharge

The most significant finding to emerge from the literature is not simply that Lagos faces a groundwater crisis, but that the solution to that crisis is already present in the city in the form of the stormwater currently causing its floods.

Research by Olabode and Comte (2024) established that the volume of excess stormwater runoff generated across Lagos during the rainy season is more than double the volume required to meaningfully replenish depleted aquifers through Managed Aquifer Recharge. This figure is drawn from a single study, and while it is a reasonable evidentiary anchor for the argument that follows, corroborating research would strengthen confidence in the scale of the opportunity. Rather than being discharged through overwhelmed drainage systems inundating homes and contaminating wells in the process, this water could be captured, treated where necessary, and injected underground to restore aquifer levels, push back saltwater intrusion, and reduce the land subsidence that worsens flood exposure.

Multiple MAR techniques have been identified as viable across different Lagos hydrogeological zones. In northern expanding built-up areas, where shallow unconfined aquifers are accessible, infiltration basins and shallow injection wells could capture excess stormwater as part of integrated urban planning. In coastal zones, aquifer storage and recovery schemes could store treated water underground during the wet season for extraction during dry periods, reducing the year-round pressure on coastal aquifers that drives saltwater intrusion (Olabode & Comte, 2024).

The appeal of MAR as a policy framework is that it dissolves the artificial boundary between flood management and water security: stormwater that currently causes damage as runoff can instead be captured and redirected to replenish groundwater, converting a flood hazard into a climate adaptation resource.

The Governance Gap: Why the Solution Is Not Happening

The evidence reviewed in this article points toward a clear integrated solution. The reason it is not being implemented is not technical; it is political and institutional.

Groundwater extraction in Lagos remains largely unregulated. There is no comprehensive public registry of boreholes, no enforced extraction limits, and no systematic monitoring of aquifer levels across the city. The Lagos State Water Corporation, chronically underfunded and under-infrastructured, cannot extend pipe coverage fast enough to reduce private borehole dependence. Meanwhile, flood management and water supply are administered by separate agencies with separate budgets, separate mandates, and no formal mechanism for integrated planning.

At the national level, groundwater depletion is absent from Nigeria's Nationally Determined Contributions under the Paris Agreement and from the country's National Adaptation Plan. This absence is not a reflection of the severity of the crisis the data reviewed here confirms it is severe, but of the invisibility of groundwater as a climate issue in public and policy discourse.

The communities paying the price for this governance failure are the same communities least equipped to advocate for change. Low-income residents in Ajegunle, Oshodi, and Ajah, who rely on jerry cans and hand-dug wells and bear the direct costs of flood damage, generally lack the political leverage to demand borehole regulation, MAR investment, or integrated water governance. We argue that addressing Lagos's groundwater crisis is therefore a climate justice imperative as well as a technical and environmental one.

Toward an Integrated Conceptual Framework

The evidence reviewed above points to a single causal chain rather than parallel crises. Urbanisation reduces natural recharge, which drives increased extraction, which causes land subsidence, which increases flood exposure, which contaminates shallow aquifers, which renders groundwater further unsuitable for use and drives still deeper extraction. This is a reinforcing feedback loop rather than a linear sequence: contamination and subsidence both loop back into extraction pressure, accelerating the same urbanisation-driven decline that started the cycle. Figure 2 depicts this relationship and positions Managed Aquifer Recharge as the single intervention point capable of breaking the loop at two places simultaneously, reducing flood volume by capturing stormwater, and reversing depletion by restoring recharge, which is why it is treated in this article as a structural solution rather than one option among several.

Figure 2. Conceptual Framework: The Groundwater–Flooding Feedback Loop in Lagos

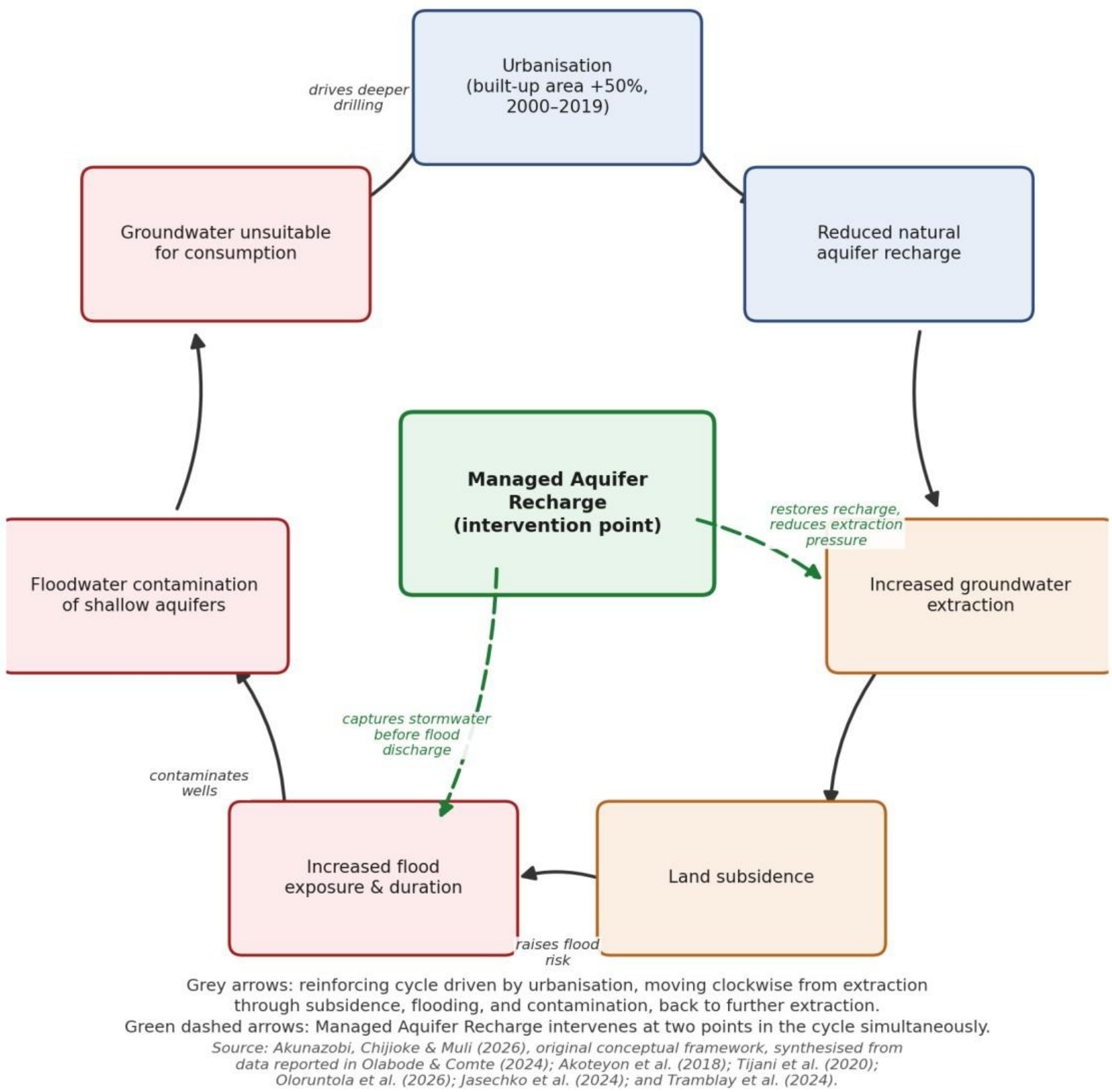

Figure 2. Conceptual framework of the groundwater–flooding feedback loop in Lagos. Authors' original conceptualisation, synthesised from data reported in Olabode & Comte (2024), Akoteyon et al. (2018), Tijani et al. (2020), Oloruntola et al. (2026), Jasechko et al. (2024), and Tramblay et al. (2024).

CONCLUSION

Lagos is not short of water. It is short of the governance, the infrastructure, and the political will to manage the water it has. Every rainy season, billions of litres of stormwater flood through its streets, destroying property, displacing families, and contaminating the wells that those same families depend on. Underground, aquifers that took decades to fill are being emptied faster than rainfall can restore them, and saltwater is advancing quietly into the spaces left behind.

The evidence reviewed in this article makes three things clear. First, groundwater depletion and urban flooding in Lagos are not separate crises; they are the same crisis expressed at different elevations, driven by the same forces of unplanned urbanization and climate change. Second, the solution to both problems exists and is well documented. Managed Aquifer Recharge offers a framework for turning flood hazard into a groundwater resource, and the hydrogeological conditions for its implementation across Lagos have already been mapped. Third, the primary obstacle is not scientific or technical but political: groundwater remains invisible in Nigeria's national climate adaptation agenda, and the communities most affected by its loss have the least power to change that.

For residents of Oshodi, Ajah, and Ajegunle whose boreholes run dry or turn saline each year, this is not an abstract policy debate but a matter of daily survival. African cities cannot build genuine climate resilience while the water beneath their feet disappears unacknowledged. Lagos must treat its groundwater emergency with the same urgency it brings to flood response, because the two are, in the end, the same emergency.

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