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Modelling, Forecasting, and Risk Assessment of Water Supply Resilience in the West African Aviation Industry: Evidence from Murtala Muhammed International Airport, Nigeria

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ABSTRACT
Airports in developing regions increasingly face challenges of inadequate water supply, which undermines operational reliability, passenger safety, and public health. This study investigated the water supply system of Murtala Muhammed Airport (MMA), Lagos—the busiest airport in West Africa—through laboratory analyses, operational data, and statistical modelling. Water samples were collected once from four points (raw intake, clarifier, treated outlet, and staff boreholes) and analysed for physicochemical and microbial quality using APHA, WHO, and NSDWQ standards. Results revealed effective treatment, with turbidity (≤0.55 NTU), iron (≤0.01 mg/L), and microbial counts compliant with WHO guidelines. However, conductivity remained consistently elevated (4.6–4.9 mS/cm), indicating salinity intrusion. Installed storage capacity (2.87 million m³/day; effective 2.44 million m³/day) marginally exceeded current demand (2.03 million m³/day), providing only a narrow resilience margin. Forecasting with compound growth modelling projected deficits by 2028 under baseline passenger growth (8.31% annually), and by 2027 under high-growth conditions. Risk assessment identified pipeline leakage and peak-period deficits as high risks, while long-term shortages and regulatory non-compliance constituted extreme risks. The integration of modelling, forecasting, and risk analysis highlights the fragile state of MMA's water supply system and its vulnerability to future demand pressures. Urgent measures, including desalination to address salinity, capacity expansion, leakage reduction, and strategic demand management, are recommended to strengthen resilience, ensure compliance with ICAO/WHO standards, and secure sustainable water supply for aviation operations.

Keywords: Water supply resilience; Airport infrastructure; Groundwater quality; Forecasting and modelling; Risk assessment; Murtala Muhammed Airport (Nigeria).

Highlights

- Comprehensive evaluation of water supply at West Africa's busiest airport (MMA, Lagos).
- Physicochemical and microbial water quality compared against WHO/NSDWQ standards.
- Conductivity consistently exceeded limits, indicating salinity intrusion despite effective treatment.
- Installed capacity marginally exceeded demand, leaving a limited margin of resilience.
- Modelling and forecasting projected deficits by 2028 under baseline growth and 2027 under high growth.
- The risk assessment identified extreme vulnerabilities, requiring urgent engineering and policy interventions.

I. INTRODUCTION

Airports constitute a critical component of infrastructure that underpins economic development, connectivity, and international trade, particularly within developing nations. Nonetheless, they frequently encounter significant challenges related to water supply systems, which are essential for operational efficiency, passenger safety, and public health (UNICEF, 2024). In Nigeria, the Federal Airports Authority of Nigeria (FAAN), established pursuant to Act No. 9 of 1996, oversees all airports and bears direct responsibility for ensuring the provision of reliable services. Despite an increase in air traffic since the 1970s, water infrastructure at numerous airports, notably Murtala Muhammed Airport (MMA) in Lagos—the largest airport in West Africa—has not expanded proportionally to meet demand (World Bank, 2021). Globally, water supply deficiencies remain considerable, with 2.2 billion individuals lacking access to safe drinking water (WHO/UNICEF, 2023). Sub-Saharan Africa bears the most significant burden due to rapid population growth, inadequate governance, and persistent underinvestment in water infrastructure (Sanitation and Water for All, 2022). In Nigeria, approximately 26.5% of the population has access to safely managed water services, while intermittent supply and substandard quality are widespread (UNICEF, 2024). These infrastructural deficits lead to recurrent health issues, including diarrhoeal diseases and waterborne infections, which disproportionately affect vulnerable communities.

In airports, risks from a poor water supply increase due to high passenger numbers, operational needs (such as firefighting, cooling, cleaning, and catering), and the potential for cross-border disease spread. Research shows inadequate water facilities pose a threat to passenger safety and efficiency at African airports (Bashir et al., 2022; Ademiluyiet al., 2023). Nigerian airports, however, are underrepresented in studies on water supply, quality, and resilience. The institutional framework complicates matters: FAAN manages water systems, but chronic underfunding, ageing infrastructure, and weak coordination with water agencies hinder progress (World Bank, 2021). While standard treatment methods, such as sedimentation, aeration, and chlorination, are employed, their effectiveness depends on effective management, adequate investment, and adaptation to issues like salinity intrusion (Adewumiet al., 2024).

MMA's reliance on boreholes, limited storage capacity, and inconsistent treatment protocols raises significant concerns regarding the sustainability of its long-term water supply. Reports indicate issues such as low water pressure, intermittent supply, and water quality deficiencies. Given MMA's strategic importance, a comprehensive and systematic investigation is necessary. This study intends to: (1) assess water coverage and storage capacities; (2) analyse water quality in comparison to WHO and NSDWQ standards; (3) project future water demand; and (4) identify measures to enhance the resilience of water supply systems.

II. MATERIALS AND METHODS

2.1 Study Area

Murtala Muhammed Airport (MMA) in Ikeja, Lagos, Nigeria, was selected as the study site. It is situated between latitudes 6°32′29″N and 6°36′33″N, and longitudes 3°18′11″E and 3°20′54″E, encompassing approximately 17.1 km². The region features a humid tropical climate characterised by bimodal rainfall patterns from April to July and September to October, with a dry season extending from November to March, consistent with the West African monsoon (NIMET, 2023). The geology predominantly consists of coastal alluvium and sandy deposits, with elevations ranging from 30 to 40 meters (Adelekanet al., 2022).

Table 2.1 – Sampling Locations, Coordinates, and Purpose

Sampling Point	Latitude (N)	Longitude (E)	Purpose of Sampling
Raw Water Source	6°35′21″	3°19′42″	Capture untreated source water quality before treatment
Settled Water (Clarifier)	6°35′30″	3°19′50″	Assess water quality after sedimentation process
Treated Water Outlet	6°35′45″	3°19′58″	Verify final potable water quality delivered to consumers
Staff Quarters Boreholes	6°35′10″–6°36′15″	3°19′20″–3°20′40″	Monitor groundwater abstraction for staff residential use

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2.2 Materials and Equipment

Sterilised polyethylene containers (1–2 L), sampling kegs, pH meter, turbidity meter, conductivity meter, spectrophotometer, and a Perkin Elmer Analyst 400 Atomic Absorption Spectrophotometer (AAS) were utilised for sampling and analytical procedures. Analytical grade reagents were employed, and personal protective equipment (PPE), including gloves, masks, and laboratory coats, was employed to ensure safety and preserve sample integrity (WHO, 2022).

2.3 Sampling Strategy

Sampling was conducted during both dry and wet seasons to account for seasonal variability. Potable water samples were collected from the raw water intake, the settled stage, the treated outlet, and staff residential boreholes (Zones A–D). Composite samples of potable water were collected early in the morning (5:30–6:00) to minimise diurnal fluctuations. All samples were preserved at 4 °C and analysed within one hour in accordance with APHA (2017) and WHO (2022) guidelines.

2.4 Laboratory Analyses

Parameters examined included physical, chemical, and selected heavy metals, as presented in Table 2.2. Standardised methods were followed, including APHA (2017) for general water tests, ASTM D1293-18 for pH, ISO 7027:2016 for turbidity, and USEPA Method 200.7 (2021) for trace metals.

Table 2.2 – Parameters Analysed, Units, Methods, and Standards

Parameter Category	Parameter	Analytical Method / Instrument	Standard Reference
Physical	Colour, Odour	Visual/organoleptic	WHO (2022)
	pH	Electrometric (pH Meter)	ASTM D1293-18
	Turbidity (NTU)	Nephelometric (ISO 7027:2016)	WHO (2022)
	Conductivity (μS/cm)	Conductivity Meter	APHA (2017)
	Total Suspended Solids (mg/L)	Gravimetric/Spectrophotometric	APHA (2017)
Chemical	Dissolved Oxygen (mg/L)	DO Meter (Membrane Electrode)	APHA (2017)
	Acidity/Alkalinity (mg/L $CaCO_3$)	Titrimetric	APHA (2017)
	Hardness (mg/L $CaCO_3$)	EDTA Titrimetric	APHA (2017)
	Chloride (mg/L)	Argentometric (Mohr Method)	APHA (2017)
	Nitrate (NO_3^-, mg/L)	UV Spectrophotometric (355 nm)	USEPA 200.7 (2021)
	Phosphate (PO_4^{3-}, mg/L)	UV Spectrophotometric (480 nm)	USEPA 200.7 (2021)
	Sulphate (SO_4^{2-}, mg/L)	Turbidimetric (680 nm)	APHA (2017)
Heavy Metals	Ca, Mg, Na, K, Zn, Mn, Fe, Ni, Co, Cd, As, Ag, Hg, Pb, Cr (μg/L)	Atomic Absorption Spectrophotometer (AAS)	USEPA 200.7 (2021)

2.5 Socio-economic and Operational Surveys

To complement laboratory findings, socio-economic and operational data were collected through structured questionnaires, semi-structured interviews, and field observations. A total of 152 households located within staff quarters across Zones A–D were randomly sampled, yielding 127 valid responses (response rate: 83.6%). The questionnaires addressed household access to potable water, consumption patterns, and perceptions of water-related health risks. Additional surveys were administered to FAAN technical staff to assess operational challenges related to water supply. Key informant interviews

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were conducted with departmental heads, while non-participatory observations documented conditions at boreholes, pumping stations, and treatment facilities (Sesanet al., 2021; UNICEF, 2024).

2.6 Ethical Considerations

Participation was voluntary, with informed consent obtained from all respondents. Confidentiality was maintained, especially for senior staff concerned about institutional sensitivities. Ethical compliance adhered to WHO (2022) guidelines for human research in WASH and FAAN research protocols.

2.7 Data Analysis

Laboratory data were analysed using SPSS v25 and MS Excel. Descriptive statistics summarised the results, and one-way ANOVA was employed to test for seasonal and spatial differences ($p < 0.05$). Heavy metal concentrations were assessed against the thresholds established by WHO (2022) and NSDWQ (2015). Survey responses were examined through frequency distributions, weighted averages, and thematic analysis of open-ended responses (Adewumiet al., 2024).

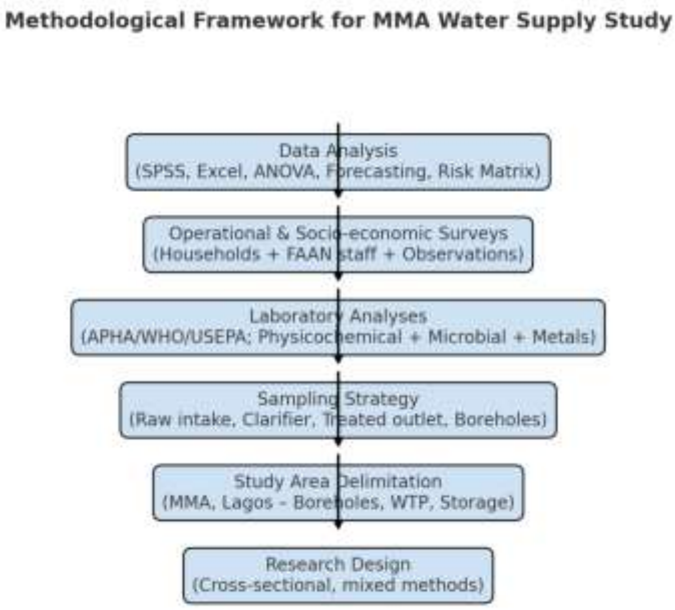

Figure 2.1 Methodological Framework diagram for the MMA water supply study.

III. RESULTS AND DISCUSSION

The assessment of water supply and sanitation at Murtala Muhammed Airport (MMA) underscores significant operational challenges that jeopardise service reliability and public health. Surveys and questionnaires indicate that water provision is insufficient, characterised by frequent outages, low pressurisation, and ageing infrastructure, thereby resulting in inadequate coverage. Additionally, sanitation facilities, drainage systems, and wastewater treatment infrastructure are deficient and necessitate urgent rehabilitation to conform to contemporary airport standards. These findings concur with recent research conducted across African airports and urban centres, which identify ageing infrastructure and limited wastewater treatment as obstacles to sustainable aviation operations (Oladokun et al., 2021; Amankwaa et al., 2023).

3.1 Water Supply Facilities at MMA

The airport's water supply system is primarily groundwater-based, supplemented by a central water treatment plant (WTP) and a distributed storage network. As shown in **Table 3.1**, MMA has a total installed storage capacity of 2,870 m³, with the main WTP accounting for over half of this volume (1,500 m³). Additional storage units are located strategically across terminals, fire stations, and staff quarters.

Table 3.1. Water Supply Storage Capacities at MMA

Schemes	**Capacity (m³)**
Water Treatment Plant (WTP)	1500
Fire Headquarters	150
Presidential Lounge	80
Fire Station	200
Near International Building	150
Hajj & Cargo	40
Zone A	60
Zone C	50
Zone D	100
Domestic Terminal 1	100
Domestic Old Water Station	440
Total	2,870

Source: Researcher's field report (2025)

The airport relies on ten boreholes with a total discharge of 305 m³/hr, as shown in Table 3.2. Wells with the highest yield, commissioned after 2010, produce over 40%, emphasising dependence on newer infrastructure. This capacity meets the current demand of 250 m³/hr, but the supply's sustainability is threatened by aging pumps and lack of backup power for booster stations. Similar issues occur at airports in Ghana and Nigeria, where reliance on boreholes and power outages threaten service reliability (Okoye et al., 2022; Tetteh et al., 2024).

Table 3.2 – Water Supply Sources and Production Capacities at MMA

Borehole Location	Commissioned	Discharge (m³/hr)	Status
Near NCAA Office	1978	0	Unserviceable
Near Pump House	1993	0	unserviceable
Near Catholic Church	2001	0	Unserviceable
Near WTP Gate	2008	0	Unserviceable
Near Fire Station	2011	40	Serviceable
Near Airfield Lighting Office	2011	45	Serviceable
Near Domestic Terminal 1 (No.1)	2012	20	Serviceable
Near Domestic Terminal 1 (No.2)	2012	25	Serviceable
Near Domestic Terminal 1 (No.3)	2013	25	Serviceable
Near Old Domestic Water Station (No.4)	2013	40	Serviceable
Behind the Fire station (3nos)	2024	120	serviceable
Total		**315**	

Source: MMIA - 1st Quarter Report, 2025

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The supply to demand ratio appears favourable, with 305 m³/hr compared to 250 m³/hr, yielding an efficiency margin of approximately 21%. Nonetheless, field surveys reveal that 71% of households continue to experience low-pressure conditions (see Section 4.10.1.8), which are likely caused by leaks, corrosion, and hydraulic head losses. This highlights the importance of non-revenue water (NRW) analysis for the effective management of urban water supply systems, as evidenced by recent research conducted in Nigeria and Ethiopia (Asfaw et al., 2022; Onwuegbucheet al., 2023).

3.2 Groundwater Quality in MMA

4.2.1 Physicochemical Parameters

pH (process control and infrastructure implications).

The ph level of the MMA groundwater was initially acidic at 5.50 ± 0.14 and persisted below the World Health Organisation (WHO) guideline range of 6.5 to 8.5 throughout both the raw and settled stages, with a recorded pH of 5.95 ± 0.07. However, the final treated water conformed to the established standards, exhibiting a pH of 6.85 ± 0.07, thus indicating successful alkalinity adjustment. Maintaining the pH within this specified range is crucial for minimising pipe corrosion and improving consumer acceptance, in accordance with WHO (2017) and Edokpayiet al. (2020).

Turbidity (clarity and disinfection readiness).

Turbidity decreased progressively from 4.50 ± 0.14 NTU in the raw water to 0.55 ± 0.07 NTU following treatment, consistently remaining below the WHO limit of 5 NTU. This outcome signifies effective coagulation and sedimentation processes, thereby ensuring enhanced clarity and disinfection efficacy. Achieving low turbidity levels (<1 NTU) is particularly crucial in preventing microbial shielding and has been highlighted as a vital global operational objective (Li et al., 2020; Ayeni et al., 2021).

Electrical Conductivity (salinity/TDS proxy).

Conductivity remained at elevated levels, increasing from 4.54 to 4.95 mS/cm, significantly exceeding the World Health Organisation (WHO) threshold of approximately 1.0 mS/cm. This demonstrates increased salinity attributable to geological and anthropogenic sources. Elevated conductivity may impact water palatability, contribute to scaling problems, and diminish industrial applicability, thereby necessitating advanced desalination techniques such as reverse osmosis or ion exchange.

Iron (aesthetic compliance; process performance).

The iron concentrations in untreated water were recorded at 0.20 ± 0.01 mg/L, surpassing the World Health Organisation (WHO) guideline of 0.3 mg/L. Post-treatment analyses demonstrated a reduction in iron levels to ≤0.01 mg/L, thereby affirming the efficacy of aeration and filtration processes in oxidizing and precipitating Fe^{2+} ions (Odukoya& Abimbola, 2019; Olalekan et al., 2020). Adequate removal of iron is essential to prevent staining, metallic taste, and clogging within distribution systems.

Dissolved Oxygen (DO, operational indicator).

The dissolved oxygen (DO) levels remained consistent across all phases, with measurements ranging from 5.01 to 5.94 mg/L, notably surpassing the 2 mg/l threshold. Although the World Health Organisation (WHO) does not provide a specific guideline for DO, adequate levels are indicative of aerobic conditions that prevent the formation of sulphides and odours (WHO, 2017; Edokpayi et al., 2020).

Total coliforms (barrier integrity).

Coliforms were absent in raw and final water (0.00 ± 0.00 cfu/mL) but present in settled water (22.00 ± 1.41 cfu/mL), indicating secondary contamination during sedimentation. This may reflect poor basin hygiene or sludge issues. The final disinfection met WHO standards of zero Escherichia coli per 100 mL, confirming chlorination effectiveness (Cecchi et al., 2020; Eze et al., 2023). Routine monitoring and maintenance are essential.

Table 3.3 – Groundwater Quality Results (MMA)

Parameter	Raw Water (Mean ± SD)	Settled Water (Mean ± SD)	Final Water (Mean ± SD)	WHO Standard	Compliance Status
pH	5.50 ± 0.14	5.95 ± 0.07	6.85 ± 0.07	6.5–8.5	Compliant (only final water)
Turbidity (NTU)	4.50 ± 0.14	2.05 ± 0.07	0.55 ± 0.07	≤5	Compliant (all stages)
Conductivity (mS/cm)	4.60 ± 0.14	4.95 ± 0.07	4.54 ± 0.09	≤1.0	Non-compliant (raw); compliant (settled)
Iron (mg/L)	0.20 ± 0.01	0.01 ± 0.00	0.00 ± 0.00	≤0.03	Non-compliant (raw); compliant (settled)
Dissolved Oxygen (mg/L)	5.01 ± 0.13	5.02 ± 0.05	5.94 ± 0.08	≥2.0	Compliant (all stages)
Total Coliforms (cfu/mL)	0.00 ± 0.00	22.00 ± 1.41	0.00 ± 0.00	0.00	Contamination in settled; compliant in raw

Source: Sample Results.

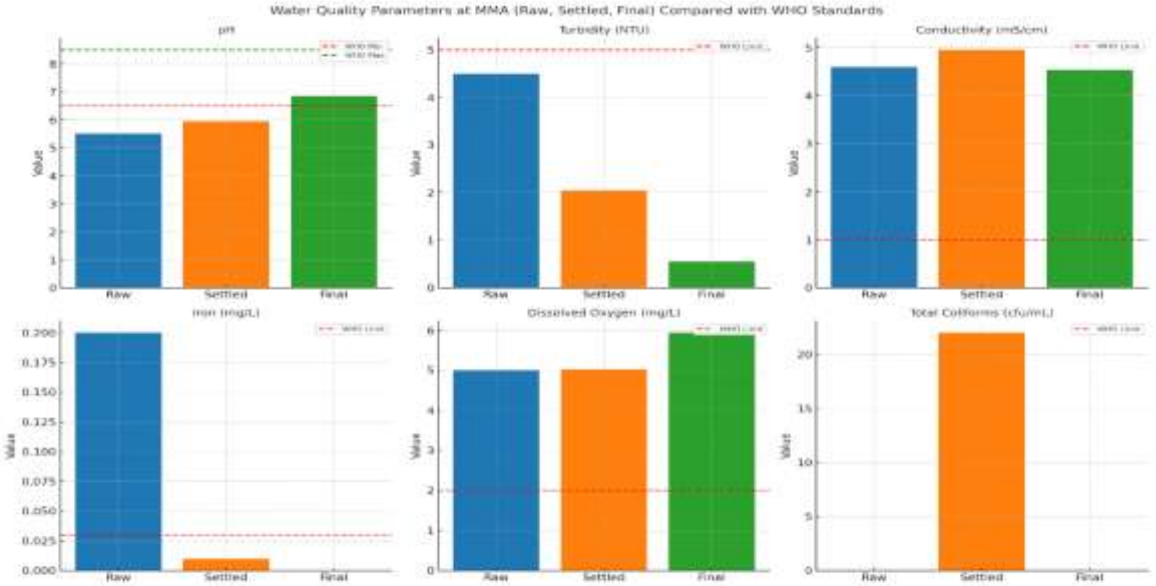

Figure 3.1: Water quality parameters at MMA (Raw, Settled, and Final stages) compared with WHO standards. Treatment reduced turbidity and iron to compliant levels and eliminated coliforms, while conductivity remained persistently above permissible limits. pH improved to within the acceptable range only in final water.

The groundwater treatment process implemented for MMA has effectively reduced turbidity, iron content, and microbial presence, thereby bringing water quality parameters closer to the standards set by the World Health Organisation (WHO). Elevated conductivity levels suggest the necessity for reverse osmosis treatment due to salinity concerns. The correction of pH has enhanced water quality; however, stabilisation is required to prevent potential corrosion. The presence of raw iron confirms that Nigerian aquifers produce Fe^{2+}, which can cause discolouration and scaling if left untreated (Olalekan et al., 2021). Transient increases in coliform counts indicate issues related to basin hygiene (Adeyemi et al., 2022). Proposed interventions include chemical stabilisation of pH, reduction of conductivity, and renewal of pipeline infrastructure, as inadequate water quality adversely affects public trust and safety (Zhang et al., 2022; Mensah et al., 2024).

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3.3 Analysis of Water Supply Levels

Baseline Capacity and Demand

Murtala Muhammed Airport (MMA) possesses an installed water capacity of 2,870,000 cubic meters per day, with an effective capacity of 2,439,500 cubic meters per day at 85% efficiency. The current demand is 2,028,216 cubic meters per day, resulting in a narrow surplus of 45,359 cubic meters per day and a supply–demand ratio of 1.02:1. Data derived from operational records indicate a critical buffer, comparable to East African airports where limited capacity has led to service strain during peak periods (Abebe et al., 2021). The World Health Organisation (WHO) guidelines caution that such minimal surpluses pose risks of service interruptions during peak flows or maintenance activities. Although the system at MMA currently meets demand, it lacks adequate resilience, emphasising the necessity for capacity augmentation.

Table 3.4 Water Supply and Demand Balance at MMA

Parameter	**Value**
Installed capacity (m³/day)	2,870,000
Efficiency (%)	85
Effective capacity (m³/day)	2,439,500
Current demand (m³/day)	2,028,216
Supply–demand ratio	1.02 : 1
Shortfall (m³/day)	45,359
Passenger growth rate (%)	8.31 (annual)
Projected adequacy	<10 years before deficit

Forecasting Model

To assess future adequacy, demand was projected using the **compound growth model**:

$$\mathbf{D_t = D_0 \times (1 + r)^t} \qquad \mathbf{3.1}$$

where D_t is demand at year t, D_0 is baseline demand (2,028,216 m³/day in 2025), ris the annual passenger-driven demand growth rate (0.0831), and t is the number of years after 2025.

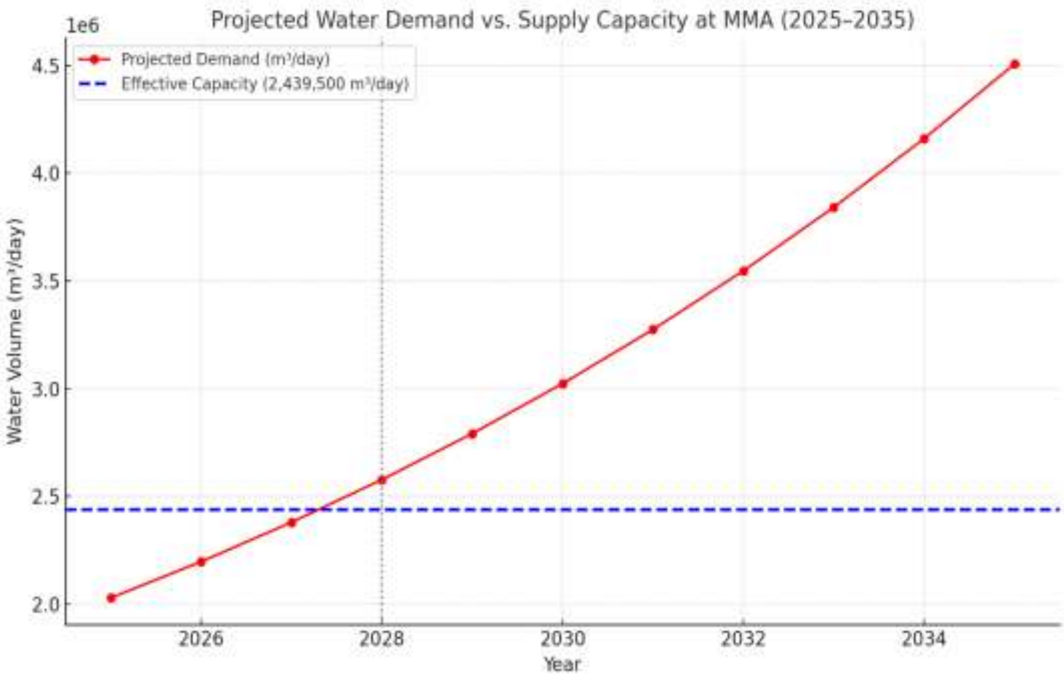

Figure 3.2 – Projected water demand versus adequate supply capacity at MMA (2025–2035). Demand is expected to exceed capacity by 2028 under baseline growth conditions.

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This model presumes exponential growth, aligning with passenger increases observed at airports in Sub-Saharan Africa. At an annual growth rate of 8.31%, demand is projected to exceed capacity by the year 2028. Nairobi's Jomo Kenyatta Airport has experienced comparable deficits, with growth surpassing supply within a decade (Njoroge et al., 2023). Concerning MMA, unless mitigative actions are undertaken, deficits are anticipated to emerge in less than three years, thereby jeopardising operational stability and water security.

Sensitivity Analysis and Projections

A sensitivity analysis was conducted incorporating alternative growth rates of 5% (low) and 10% (high) to assess the robustness of the projections. Under the low-growth scenario, MMA's supply remains sufficient until 2030, with shortages emerging in 2031. Conversely, with a baseline growth rate of 8.31%, shortages are expected to occur by 2028, whereas accelerated growth precipitates scarcity by 2027. These findings demonstrate that even slight variations in passenger growth significantly alter the timeline for supply inadequacy. This sensitivity aligns with findings at Addis Ababa Bole International Airport, where minor deviations in traffic growth accelerated water shortages by several years (Abebe et al., 2021). The implication is that MMA's current buffer is highly vulnerable, offering only a 2–6 year window for intervention, contingent upon the growth rates.

Table 3.5 – Water Demand Projections at MMA under Different Growth Scenarios

Scenario	Growth Rate (%)	Deficit Year	Year Capacity Exceeded	Notes
Low Growth	5.0	2031	2031	Adequate until 2030
Moderate Growth (Baseline)	8.31	2028	2028	Surplus exhausted within 3 years
High Growth	10.0	2027	2027	Deficit emerges in 2 years

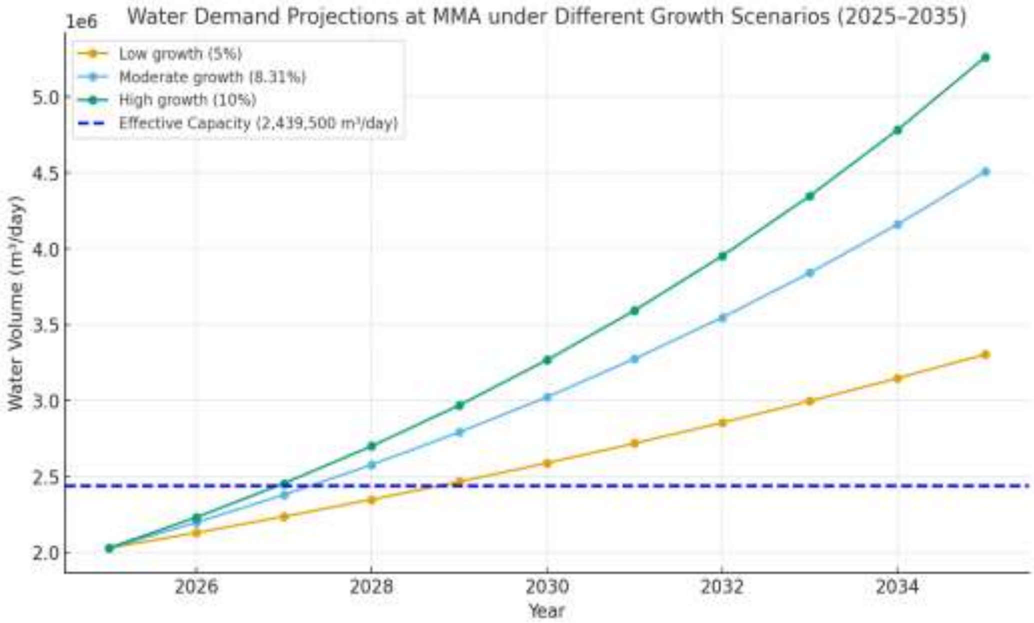

Figure 3.3 – Water demand projections under low (5%), moderate (8.31%), and high (10%) growth scenarios compared with adequate capacity. Deficits occur by 2031, 2028, and 2027, respectively.

Risk Assessment

Table 3.6 delineates the risk matrix, illustrating vulnerabilities within the MMA water system. Long-term deficits exceeding ten years are nearly inevitable with substantial impacts, constituting extreme risks. Medium-term deficits, occurring within five years, and non-compliance with ICAO and WHO standards are categorised as

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very high risks. Short-term deficits during peak demand periods and pipeline leakage are classified as high risks, whereas microbial recontamination at sedimentation basins is considered a medium risk. These findings align with safety guidelines, which underscore the importance of compliance and systemic capacity issues as significant operational threats (ICAO, 2018). The vulnerability of MMA is predominantly structural and regulatory, rather than solely operational, thereby necessitating comprehensive reforms.

Table 3.6 Risk Matrix for MMA Water Supply

Risk Factor	Likelihood	Impact	Risk Level
Short-term deficit (peak demand days)	Medium	High	High
Medium-term deficit (within 5 years)	High	High	Very High
Long-term deficit (>10 years)	Almost Certain	Very High	Extreme
Infrastructure failure (pipeline leakage)	Medium	Medium–High	High
Microbial recontamination in sedimentation	Medium	Medium	Medium
Regulatory non-compliance (ICAO/WHO)	High	High	Very High

Figure 3.4:Colour-coded risk matrix for MMA water supply showing likelihood–impact positioning. Long-term deficits are extreme, medium-term deficits and regulatory non-compliance are very high, while short-term deficits and pipeline leakage are high risks.

Comparative Insights and Implications

The water supply vulnerability of MMA reflects patterns observed at other African airports. In Addis Ababa, delays in expanding water treatment facilities have resulted in rationing and bottlenecks (Abebe et al., 2021). Jomo Kenyatta International Airport in Nairobi has experienced recurrent shortages due to underinvestment, thereby endangering public health (Njoroge et al., 2023). If proactive interventions are not implemented promptly, MMA may encounter similar challenges. It is essential that planning extends beyond routine upgrades to encompass: (i) the expansion of treatment and storage capacities, (ii) the reduction of leakage and enhancement of energy efficiency, (iii) the adoption of greywater recycling for non-potable applications, and (iv) the integration of demand forecasting into long-term strategic planning.

3.4 Synthesis

The evaluation of water supply at Murtala Muhammed Airport (MMA) reveals both short-term compliance and long-term fragility. Laboratory results show that treatment processes successfully reduced turbidity, iron, and microbial loads to WHO-compliant levels, ensuring immediate water safety. However, conductivity remained significantly elevated, indicating persistent salinity intrusion that could compromise

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potability, infrastructure, and consumer trust. Storage and production capacities currently exceed demand, but only by a narrow margin, leaving the system highly vulnerable to disruptions. Forecasting projects deficits by 2028 under baseline passenger growth and by 2027 under high-growth scenarios. Risk assessment highlights short-term shortages, leakage, and long-term non-compliance as critical threats. Urgent engineering interventions and policy reforms are required to secure resilient, safe, and sustainable airport water supply.

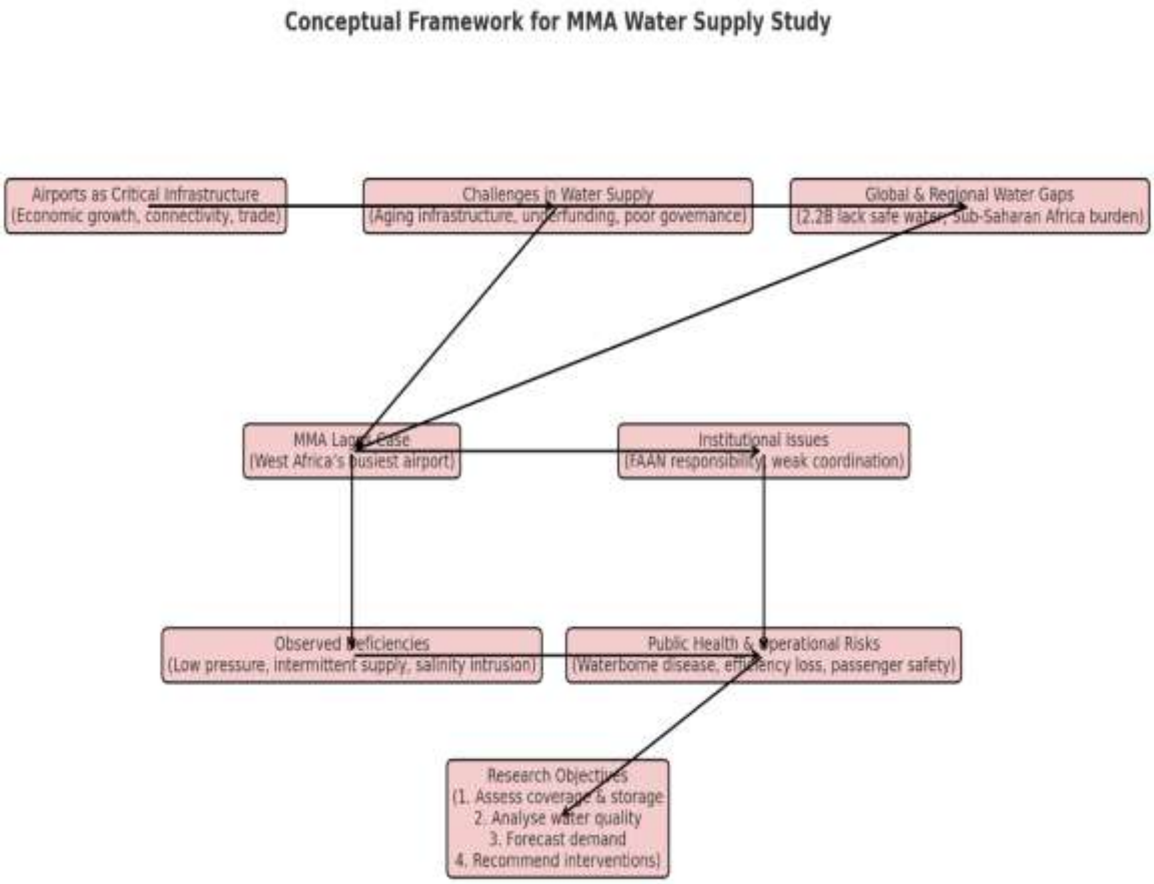

Figure 3.5Conceptual Framework for MMA Water Supply Study.

IV. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

This study evaluated the adequacy, quality, and resilience of water supply systems at Murtala Muhammed Airport (MMA), Lagos. The findings affirm that treatment processes have effectively reduced turbidity, iron, and microbial contamination to meet WHO and NSDWQ standards, thereby providing safe water at the point of delivery. However, persistently elevated conductivity indicates salinity intrusion, which poses a threat to long-term potability and infrastructure reliability. Installed storage and production capacities slightly surpass current demand, resulting in only a marginal buffer. Forecasts project deficits emerging by 2028 under baseline passenger growth and by 2027 under accelerated growth. Additionally, risk assessments highlight extreme vulnerabilities associated with leakage, non-compliance, and long-term sustainability. Without immediate interventions, the water system at MMA will face critical shortages, jeopardising public health, operational reliability, and compliance with ICAO and WHO standards.

4.2 Recommendations

- ✶ Capacity Expansion: Upgrade the central treatment plant and expand storage facilities to meet projected passenger-driven demand beyond 2030.
- ✶ Salinity Control: Implement desalination measures, such as reverse osmosis or ion

exchange, to address persistent conductivity exceedances.

- Leakage Reduction: Implement active non-revenue water (NRW) management, including pipe replacement, pressure regulation, and hydraulic monitoring.
- Resilience Enhancement: Establish standby pumps, alternative energy sources, and greywater recycling for firefighting and non-potable uses.
- Policy and Governance: Strengthen coordination between FAAN and regulatory agencies (NSDWQ, NESREA) to enforce compliance and secure funding.
- Strategic Planning: Integrate demand forecasting into airport master planning to ensure sustainable, long-term water security.

Policy Statement

Securing a sustainable water supply at MMA requires prompt investment in capacity expansion, operational efficiency enhancements, and proactive governance reforms. Through the implementation of advanced demand management and infrastructure upgrades, MMA can ensure service reliability, adhere to ICAO and WHO standards, and position itself as a regional exemplar in resilient aviation infrastructure.

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Authors contributions

Gambo A.T: Conceptualisation, model development, data analysis, manuscript drafting.
Adefisoye S.A: Methodology design, and critical review.
Coker A.O : Validation, interpretation, editing, overall supervision.
All authors have read and approved the final version of the manuscript.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data supporting this study, including laboratory results, model inputs, and calculation records, are available from the corresponding author upon reasonable request.

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