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Systems-Based Approach to Improving Urban Water Access in Low-Income Communities

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44%
of Lagos residents have physical access to the public water network [1]

UP TO 60%
of distributed piped water lost to leaks and inefficiency [2]

8.9%
of Lagos residents have a safely managed water supply [3]

₦4 – 6k
per m³ paid to vendors on Lagos Island, 4–6× a ₦1,000 kiosk price [4]

SIMULATED

2×
more hours of water a day when kiosk nodes hold one day of storage

1 Why it matters

Lagos needs about **540 million gallons** of water a day but the public system can produce about **210**, and up to 60% of what it distributes is lost [2]. In low-income settlements the gap is filled by vendors and private boreholes, at high cost and often unsafe quality.

This study treats urban water access as a **multi-stakeholder system** rather than an isolated infrastructure problem, and asks where intervention changes the behaviour of the whole system.

1. Identify the systemic bottlenecks that limit water access in low-income communities.
2. Map how infrastructure, stakeholders and policy interact, using systems thinking tools.
3. Propose and test a systems-based intervention framework.

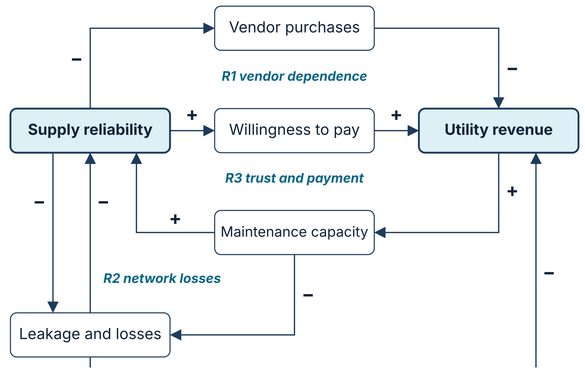
2 Who shapes the system

- **State government & regulator** — Tariffs, quality and vendor licensing rules
- **Water utility** — Treatment, distribution, metering, repairs
- **NGOs & donors** — Capital for pilots, technical assistance
- **Informal vendors** — Last-mile supply by cart, tanker, borehole
- **Households & communities** — Demand, payment, fault reporting

3 Method

1. **Secondary data** — Published studies, utility statements, survey data, investigative reports
2. **Stakeholder mapping** — Roles and levers of five actor groups
3. **Root-cause analysis** — Causal loops and Ishikawa diagrams
4. **Framework design** — Model-based systems engineering of four modules
5. **Metrics & targets** — Five measurable indicators for a pilot
6. **Scenario simulation** — Monte Carlo kiosk model, 2,000 one-year runs

4 Why service stays poor: three reinforcing loops



+ moves in the same direction · **–** moves in the opposite direction · **R** reinforcing loop.

R1 Vendor dependence
Spending leaves the utility for vendors.

R2 Network losses
Leaks drain revenue and maintenance.

R3 Trust and payment
Poor service lowers willingness to pay.

5 The framework: four modules, one closed loop

01 INFRASTRUCTURE LAYER
Localised kiosk nodes
Local storage, treatment and metered dispensing
Weakens R1

sensor data →

02 INFORMATION LAYER
Monitoring & diagnostics
Pressure, flow, level and quality telemetry with anomaly detection
Weakens R2

↑ sales revenue

↓ fault alerts

04 ECONOMIC LAYER
Market integration
Registered vendors, price ceiling, targeted subsidies
Weakens R1

← pricing rules

03 INSTITUTIONAL LAYER
Adaptive governance
Roles, fault escalation, response times, rule review
Weakens R3

7 Two settings, two water problems

Lagos Island
Itafaji · Onola · Adeniji Adele

₦100–150
per 25 L jerrycan from vendors [4]

- Residents report **never** having public water
- Groundwater TDS above **8,500 mg/L**, too salty for boreholes

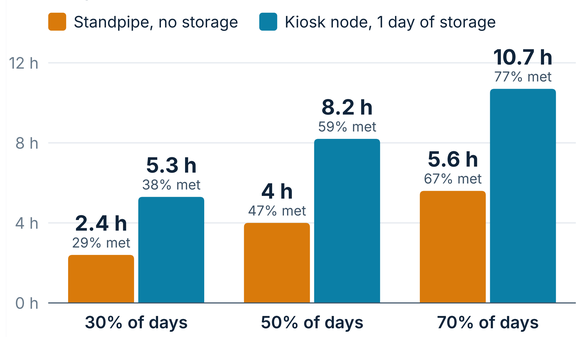
Yaba
Makoko waterfront

₦10
per bucket from borehole points [5]

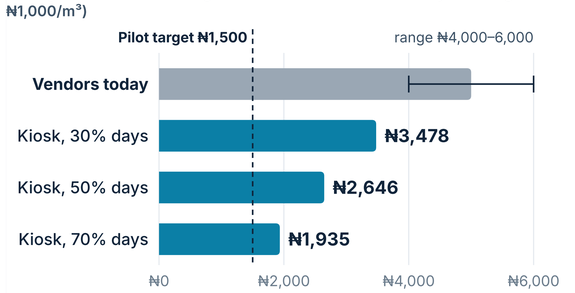
- Household of six spends **₦100–200** a day
- ***E. coli*** and acidic water found in tests

8 Scenario simulation: what kiosk storage buys

Hours of water a day at the node for 5,000 residents at 50 L per person [6], by share of days the trunk main delivers



Average cost of water on Lagos Island with a kiosk node (1 day of storage, ₦1,000/m³)



Simulated scenario outputs, not measurements: means of 2,000 one-year runs; 3-day mean outages; 40 m³/h feed for 4–12 h on supply days; shortfall bought at current prices [4][5].

9 What the simulation shows

2× **Storage roughly doubles** daily water hours at every supply level.

–60% On **Lagos Island** the cost of water falls from about ₦5,000 to ₦1,935 per m³.

95% of demand met once feed is doubled and outages shortened to 1 day. **Storage must match outage length.**

Safe In **Yaba** cash cost rises slightly (₦750 → ₦900/m³); the gain is **safe water**.

10 How success is measured

METRIC	BASELINE	PILOT TARGET
Reliable service hours	2.4–5.6 h (simulated, no storage)	≥ 12 of 14 h
Water quality compliance	To be measured	All samples within WHO limits
Household cost per m³	₦4,000–6,000 (Lagos Island)	≤ ₦1,500, safe source
Non-revenue water	To be measured	20–30% reduction
Fault response time	Days to weeks	Under 24 h

11 Conclusion & next steps

Water access in low-income Lagos fails as a **system**: supply, losses, vendors and trust reinforce one another. Acting on all four modules together targets every loop at once.

1. Costed design for one community cluster
2. Baseline measurement of all five metrics
3. Six-month trial against a comparison cluster

Fix the loop, not just the pipe.

References

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