Assessment of Sediment Deposition and Reservoir Storage Capacity Loss at Agba Dam, Ilorin

Using Apache 5 autonomous surface vehicle-based single-beam bathymetric survey

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Presentation outline

1. Background and research gap
2. Study area and objectives
3. Methodology: control, instrumentation, processing
4. Results I: bathymetry, DTM and slope
5. Results II: EAV curves and capacity loss
6. Zonation, discussion and recommendations

Reservoir sedimentation erodes storage, and Agba Dam's loss had never been mapped

0.5–1 %

typical annual global storage loss [14]

1952

year Agba Dam was completed; first dam in Kwara State

24–25 ha

reservoir surface area at full supply level

1.344×10^6 m³

documented design storage capacity [6]

Why it matters: Agba supplies raw water to Government House, the GRA and adjoining districts of Ilorin. Sediment inflow from agriculture, urbanisation and riparian degradation threatens that function.

Prior studies lacked a continuous bed surface; this study closes that gap

Research gap

- Earlier work relied on limited station sampling [7], [8]
- Reported capacity reduction, sediment texture and turbidity
- No complete, high-resolution bathymetric surface of the whole reservoir
- Manual soundings lack the density and accuracy for reservoir-wide volumes

Objectives

1. Establish a geodetic control network
2. Acquire a complete bathymetric dataset
3. Map spatial patterns of bed morphology
4. Derive elevation–area–volume (EAV) relationships
5. Quantify current capacity and loss against design volume

Study area: an earthfill, spring-impoundment dam on River Agba

310 m

crest length

16.5 m

crest height

≈ 25 ha

open-water surface near full supply level

1.344×10^6 m^3

design storage capacity (KWSC) [6]

Spring-fed

principal source is natural spring flow, not surface runoff

Ilorin South LGA

Kwara State, Nigeria

Location: approx. 8°28′34″–8°28′42″ N, 4°35′05″–4°35′27″ E

Methodology: six-stage workflow from control to capacity loss

1 Geodetic control

KWSC Surveyor-General 2nd/3rd-order stations densified with temporary benchmarks; Minna Datum, UTM 31N

2 Autonomous survey

CHC Apache 5 USV, single-beam echo sounder, RTK-GNSS; calm conditions near full supply level

3 Quality control

4,772 raw soundings cleaned to 4,760 valid records

4 DTM and slope

Triangulation / natural-neighbour interpolation; slope derived from DTM

5 EAV curves

Successive horizontal slicing of the DTM; numerical integration of A(z)

6 Loss and zonation

Volume at 320.29 m vs design capacity; depth- and slope-based bed classification

Classified as IHO S-44 Order 1b [15]

Instrumentation: USV-mounted single-beam sounder with centimetre-level RTK positioning

Component	Specification
Platform	CHC Apache 5 unmanned surface vehicle
Echo sounder	0.3–200 m range; 0.01 m resolution; ±0.02 m + 0.1 % of depth
Positioning	CHC i50 base + rover; RTCM 3.x; fixed RTK
RTK accuracy	Horizontal ≈ 8 mm + 1 ppm; vertical ≈ 15 mm + 1 ppm
Transducer draft	Measured, typically 0.13 m
Sound velocity	≈ 1480–1500 m s^{-1} from temperature
Water surface	Mean 320.29 m (SD 0.03 m)

Depth from two-way travel time

$$d = (v \cdot t) / 2 + D_t$$

d depth, water surface to bed (m)

v sound velocity (m s^{-1})

t two-way travel time (s)

D_t transducer draft (m)

Bar-check / lead-line confirmed residual errors of a few cm

Rigorous cleaning retained 99.75 % of soundings; the water stage was effectively constant

4,772

raw soundings

12

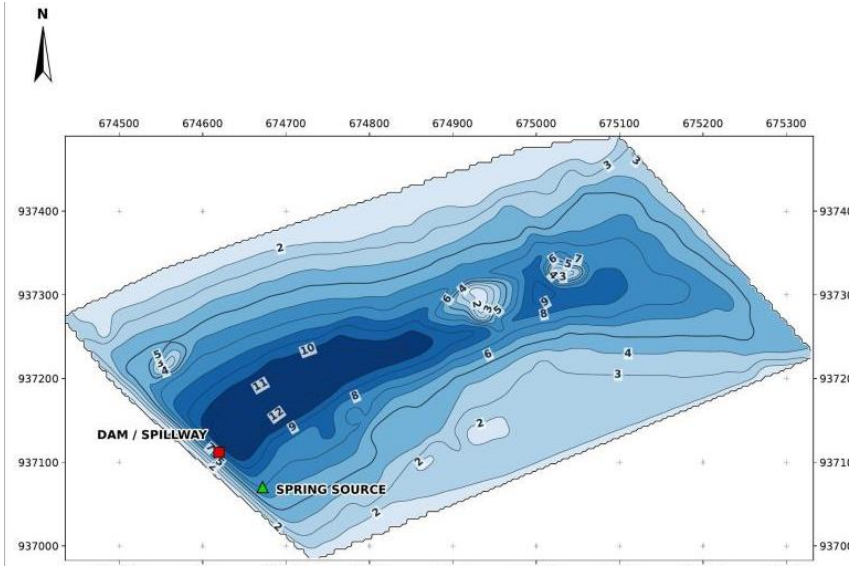
outliers removed (water-surface height > 1 m from median)

4,760

valid soundings retained (99.75 %)

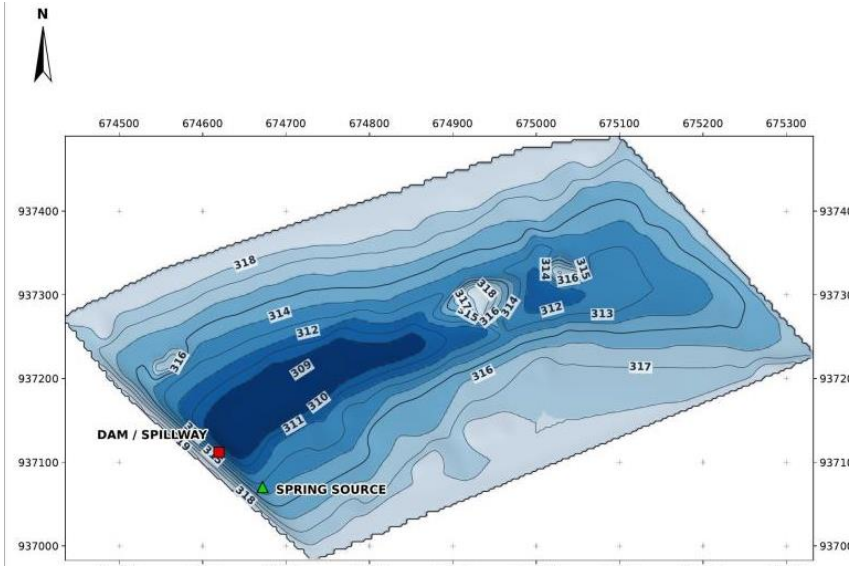
Cleaned dataset (n = 4,760)	Value
Depth range	0.13 – 13.04 m
Mean depth ± SD	5.40 ± 3.14 m
Bed elevation range	307.24 – 320.81 m
Water-surface SD	0.03 m (stage effectively constant)

Results: a basin-shaped bed, deepest beside the dam and spillway



Bathymetric map (depth below 320.29 m; 1 m contours)

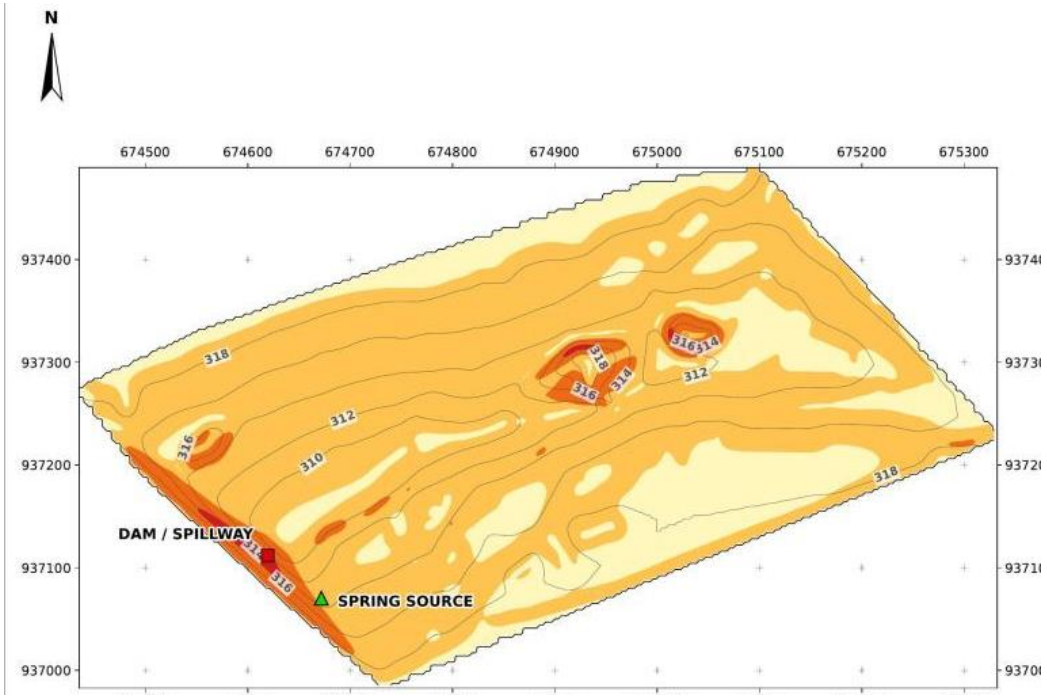
Darker blue = deeper water



Digital Terrain Model (bed elevation; 1 m contours)

Darker blue = lower bed elevation

The bed is predominantly gently sloping; steep zones cluster near the dam

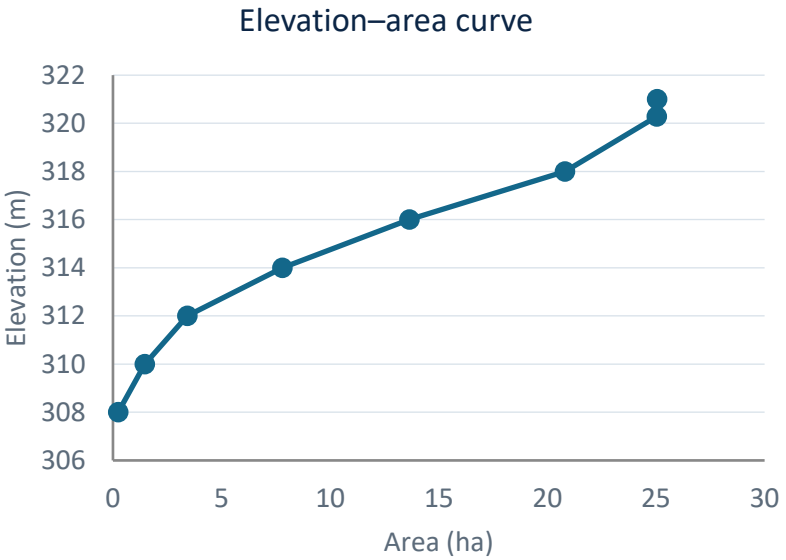


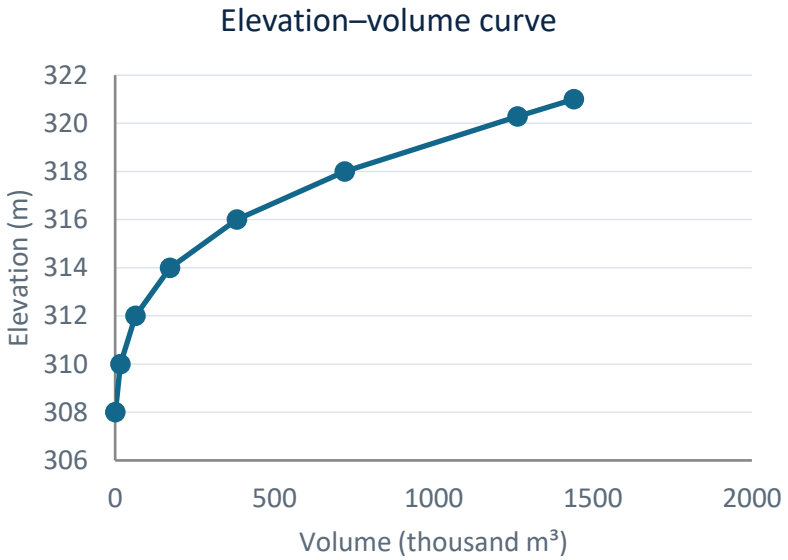


Slope map derived from the DTM

- Mostly 0–2° and 2–8° across the surveyed extent
- Localised zones > 18° at margins of the dam-proximal deep pool
- These may partly reflect residual sounding noise, so treat as indicative

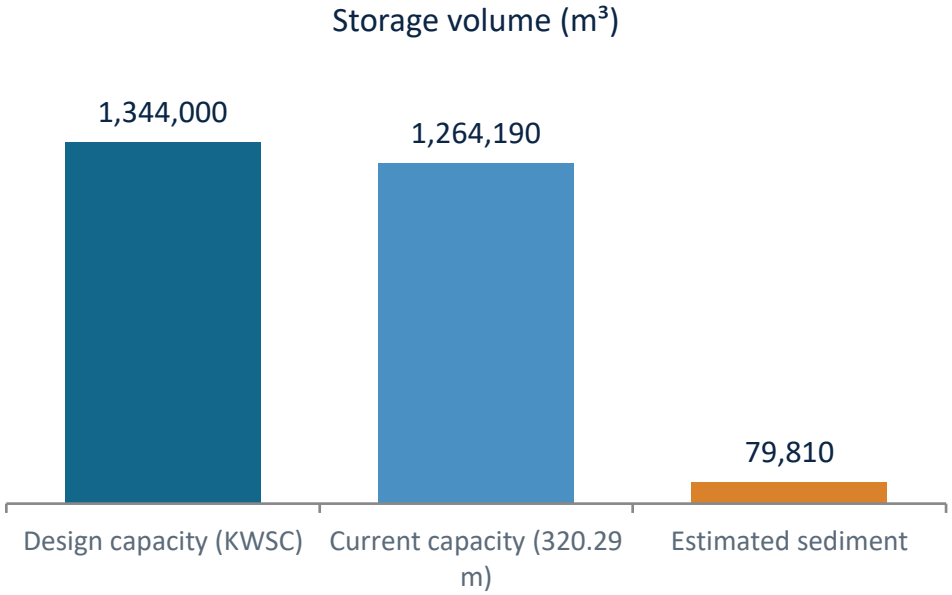
Elevation–area–volume curves give stage–storage relationships for operations





At pool level 320.29 m: area 25.04 ha | volume 1,264,190 m³ | area at 321.0 m is 25.05 ha (margins already full)

Result: 79,810 m³ of sediment, a 5.9 % loss of design capacity



1,264,190 m³

current capacity

79,810 m³

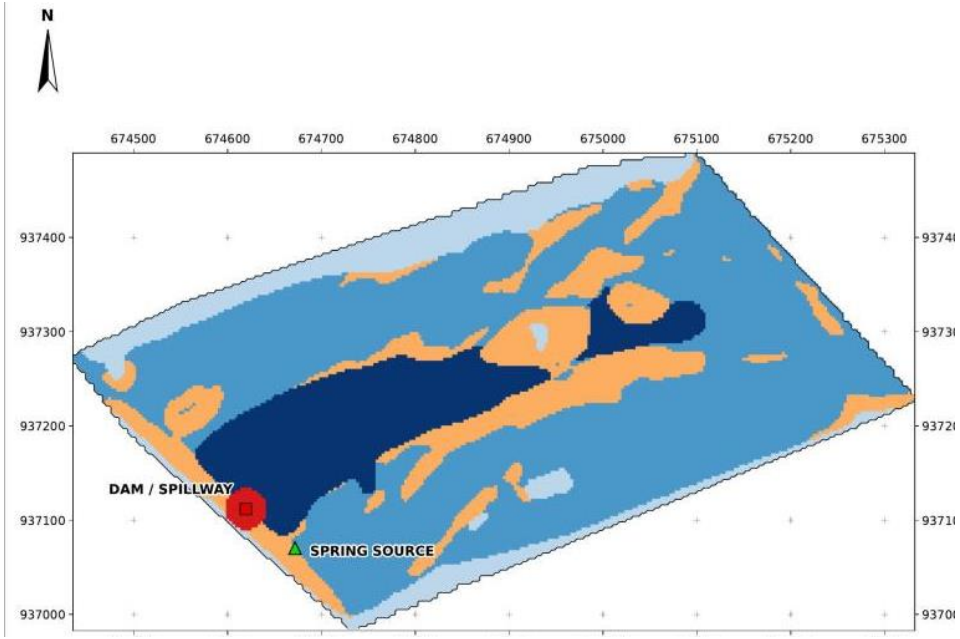
estimated sediment volume

5.9 %

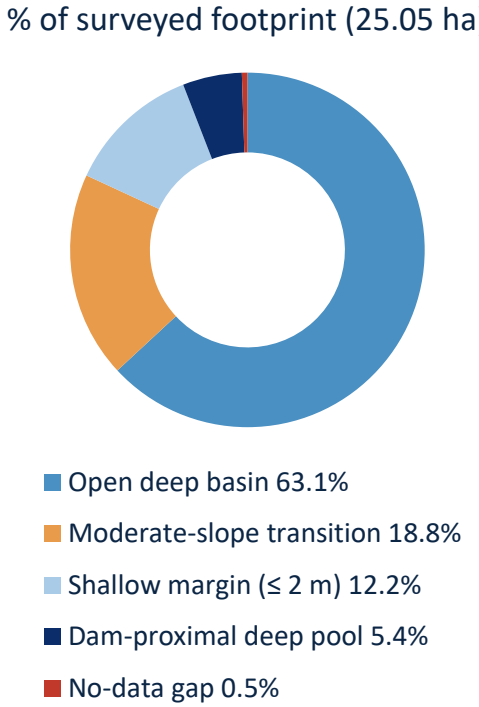
capacity loss

Loss = (1,344,000 − 1,264,190) / 1,344,000 = 5.9 % (baseline: documented KWSC design capacity)

Bed zonation: the open deep basin dominates the reservoir footprint



Interpretive classification (depth and slope), not a sediment-thickness map



Discussion: a modest loss consistent with spring-fed hydrology, with stated limits

Why modest?

- Spring baseflow carries less suspended sediment than river inflow
- River-fed Lugu, Bakolori and Angereb report much higher fractional losses [12], [13], [16]
- Age, size and catchment differ

Validation

- Computed area 25.04 ha vs reported 25.3 ha (1.0 % shortfall)
- 99.75 % of soundings retained
- IHO S-44 Order 1b survey

Limitations

- Loss is relative to documented design capacity
- Zonation is interpretive; steep zones may include noise
- Small no-data gap (0.12 ha) at the spillway
- Spring-fed explanation not directly tested

Conclusions and recommendations

Conclusions

- First spatially continuous, high-resolution bathymetric baseline for Agba Dam (4,760 soundings)
- Capacity at 320.29 m: 1,264,190 m^3; sediment 79,810 m^3; loss 5.9 %
- Open deep basin covers 63.1 % of the bed
- Low-cost USV single-beam surveying is practical for small tropical reservoirs

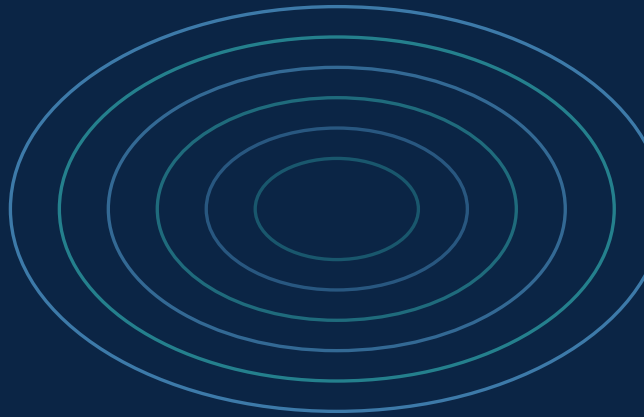
Recommendations for KWSC

1. Adopt the dataset (DTM, EAV, zonation) as the official reference
2. Prioritise maintenance on shallow margins and intake zones
3. Install a permanent water-level gauge
4. Repeat surveys periodically with the same methodology

Thank you. Questions?

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