STORE Project
Progress Report

Small Reservoir Storage Estimation – Zambezi Basin

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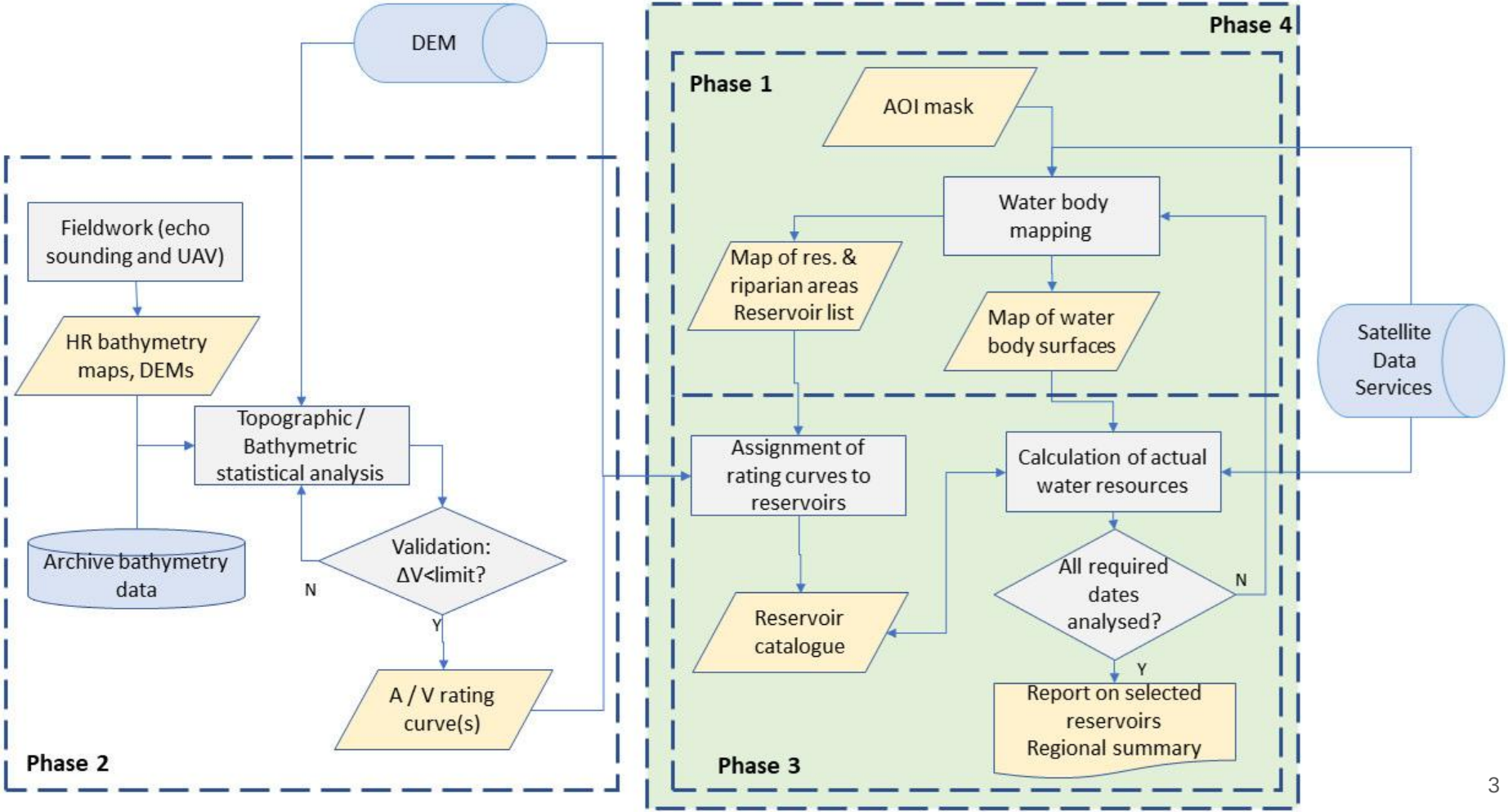
Problem definition and objectives

Small ungauged reservoirs - unknown surface water resources (climate variability, El Nino 2024) - hampered effective water management and agricultural water supply.

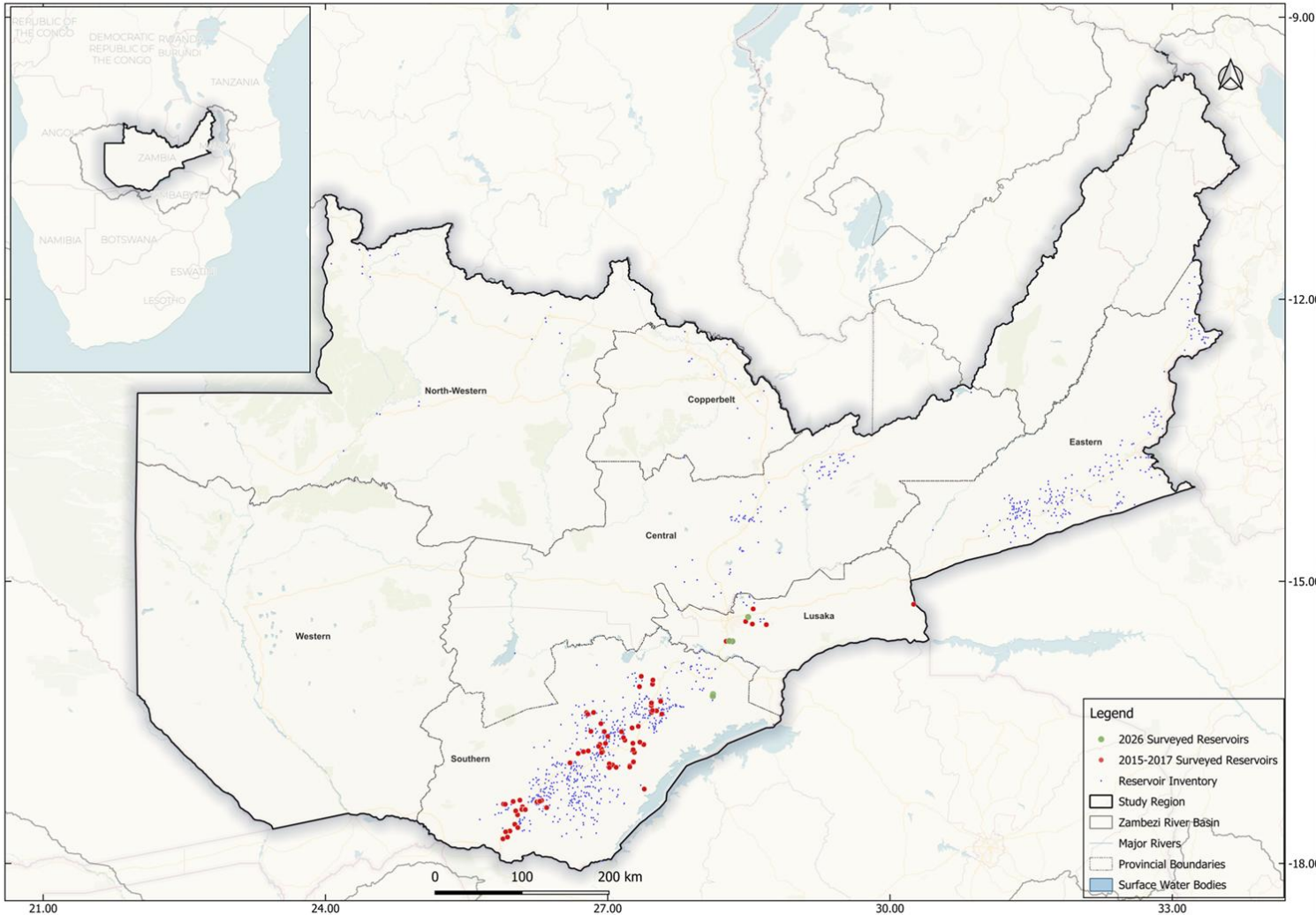
Project aim:

To develop a **comprehensive framework** for estimating **water storage dynamics** of the (small) reservoirs across the Zambezi Basin.

1. Map and catalog small reservoirs (Phase 1).
2. Assess the reservoirs' area/ volume rating curves (Phase 2)
3. Monitor storage across the basin using EO and the rating curves (Phase 3)
4. Develop a prototype dashboard to visualize (Phase 4).


DEM
Phase 4
Phase 1
AOI mask
Water body mapping
Map of res. & riparian areas Reservoir list
Map of water body surfaces
Satellite Data Services
Fieldwork (echo sounding and UAV)
HR bathymetry maps, DEMs
Topographic / Bathymetric statistical analysis
Archive bathymetry data
Validation: ΔV<limit?
N
Y
A / V rating curve(s)
Phase 2
Assignment of rating curves to reservoirs
Calculation of actual water resources
Reservoir catalogue
All required dates analysed?
N
Y
Report on selected reservoirs Regional summary
Phase 3

Study Area Map

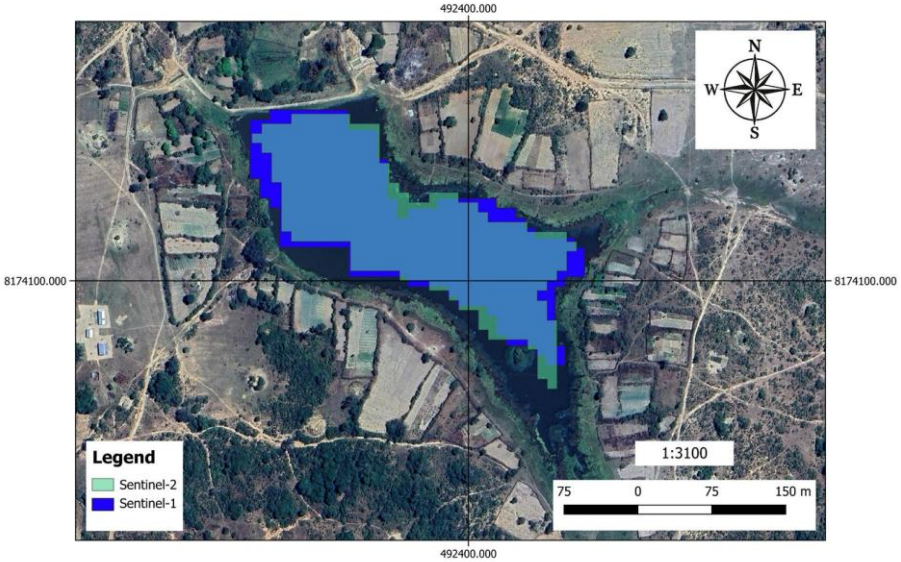


Phase 1: Reservoir Mapping Using Sentinel Imagery

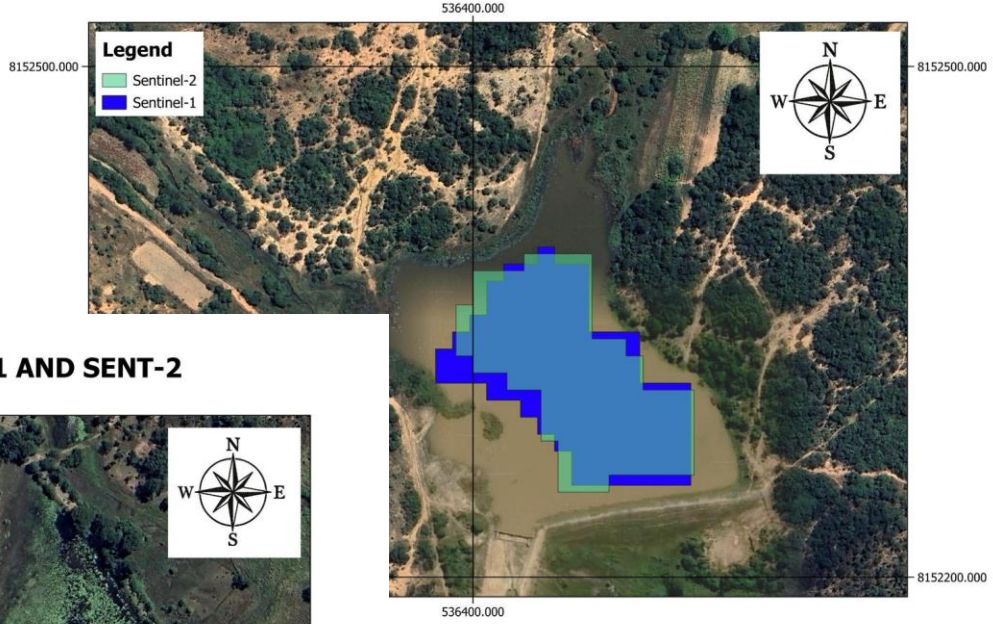
Use of Python and Jupyter Notebook to automate the creation of shapefiles depicting the total water covered area of any reservoir in Zambia.

- Sentinel 1: Refined Lee filter, Threshold at -13db,
- Sentinel 2: MNDWI at -0.01 Threshold, 0% Cloud Cover over AOI
- Output: Observed Area Extent (Excel Sheet),Shapefile, Time series Plot including Precipitation patterns (ECMWF vs CHIRPS)

MANDALA SENT-1 AND SENT-2

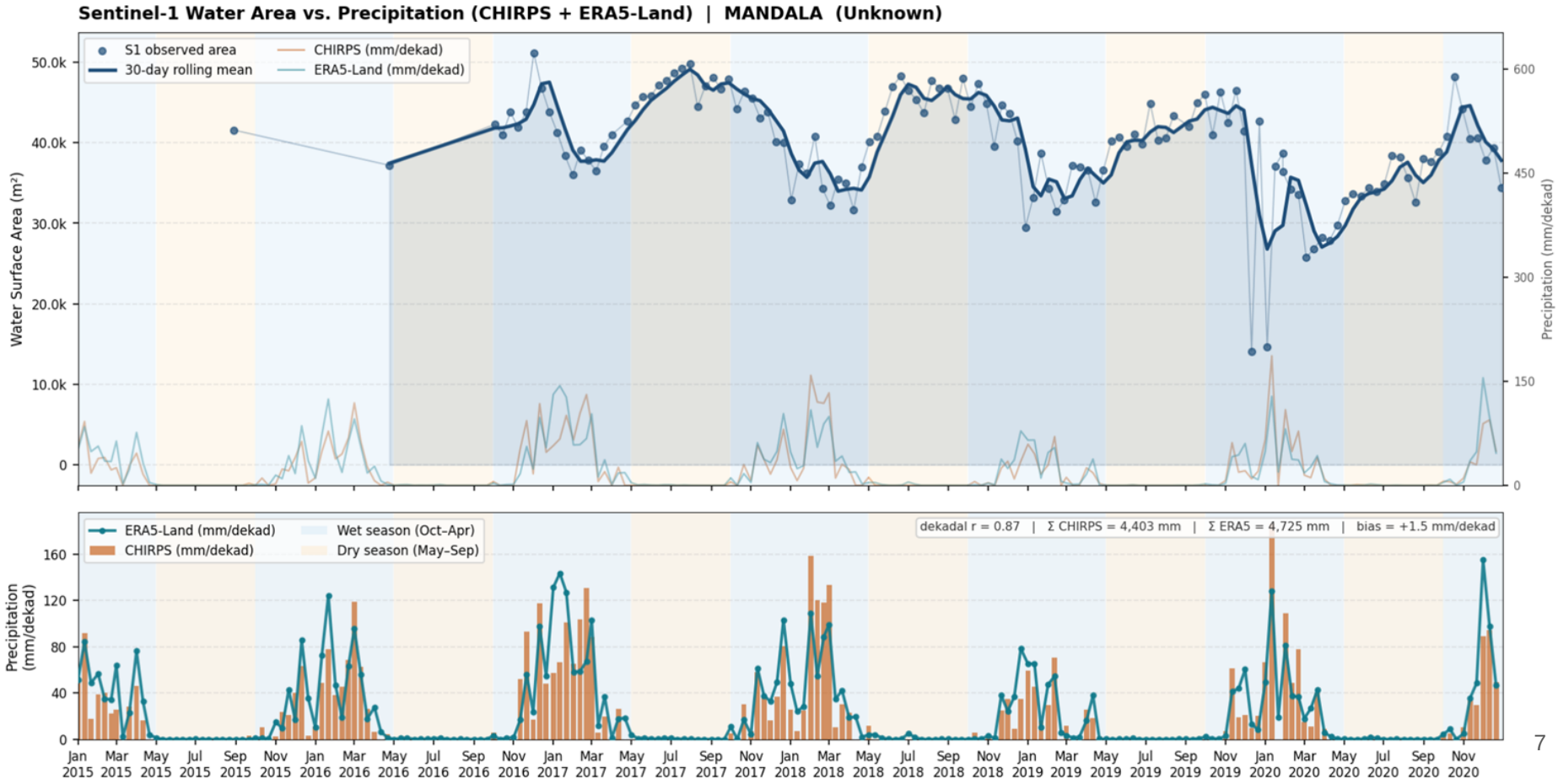


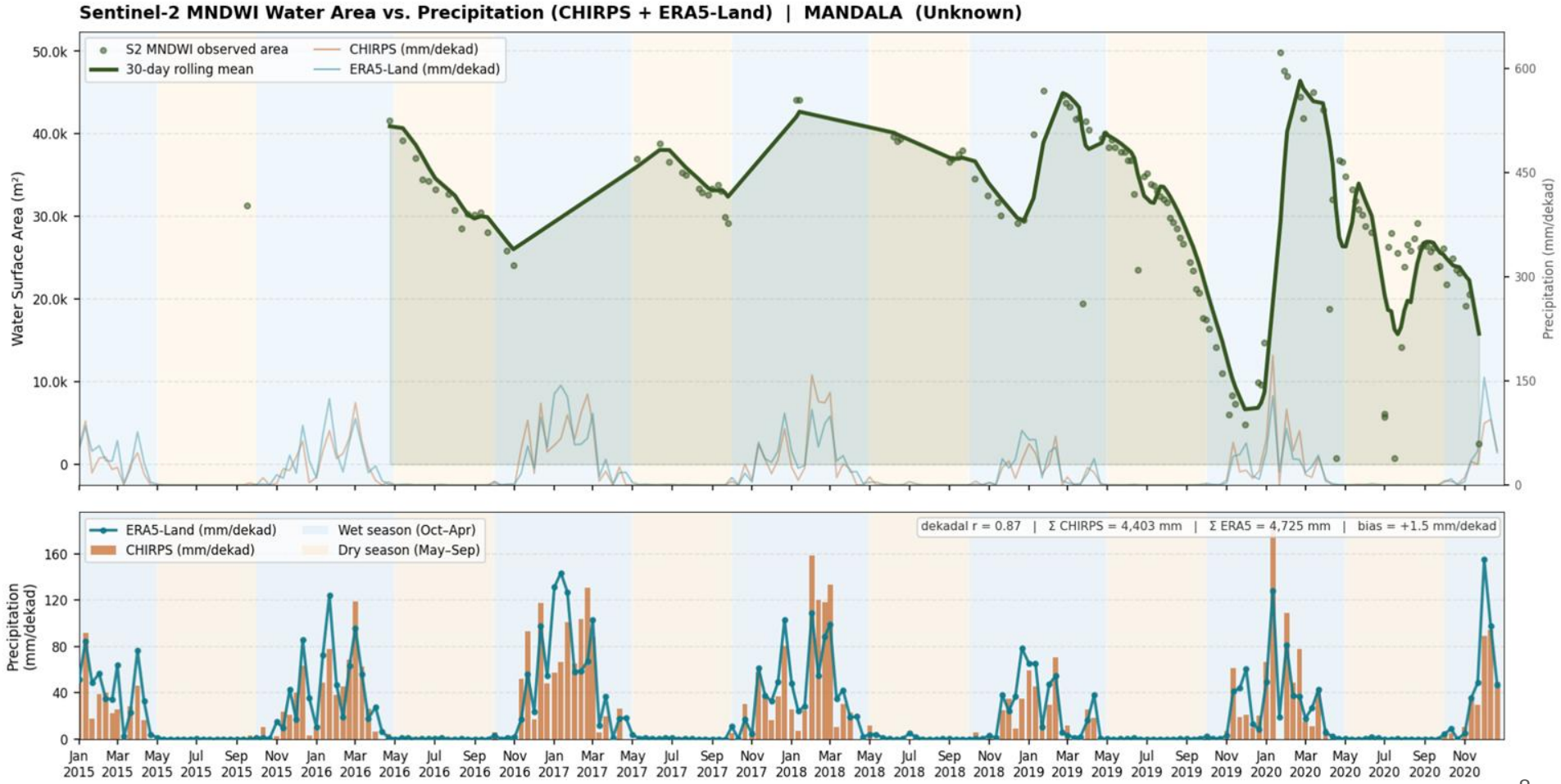
NACHIBANGA SENT-1 AND SENT-2



1 AND SENT-2

Water Area observed vs Precipitation




Sentinel-2 MNDWI Water Area vs. Precipitation (CHIRPS + ERA5-Land) | MANDALA (Unknown)
S2 MNDWI observed area
30-day rolling mean
CHIRPS (mm/dekad)
ERA5-Land (mm/dekad)
Water Surface Area (m²)
Precipitation (mm/dekad)
ERA5-Land (mm/dekad)
CHIRPS (mm/dekad)
Wet season (Oct–Apr)
Dry season (May–Sep)
dekadal r = 0.87 | Σ CHIRPS = 4,403 mm | Σ ERA5 = 4,725 mm | bias = +1.5 mm/dekad
Precipitation (mm/dekad)

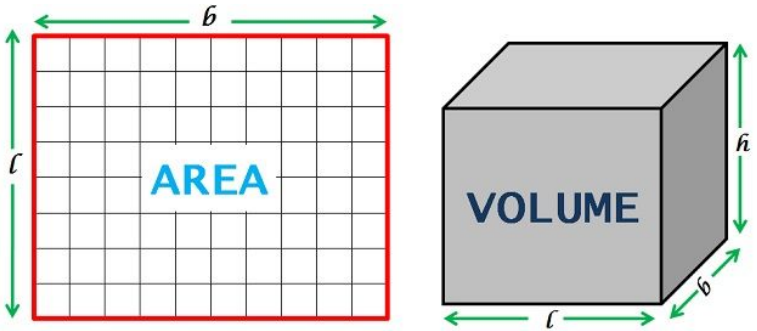
Phase 1: Challenges/Limitations/Improvements

- Reservoir size vs Satellite resolution
- Vegetation (in and around water body)
- Satellite data availability (gaps over Zambia region, Sentinel 2B absence)
- Field visits: Distance, Road access, Private/Community ownership reserves right of admission, Vegetation (influence Sonar readings)

- Use of Glofas Mask to identify newly constructed reservoirs
- Fine Tune thresholds for improved efficiency

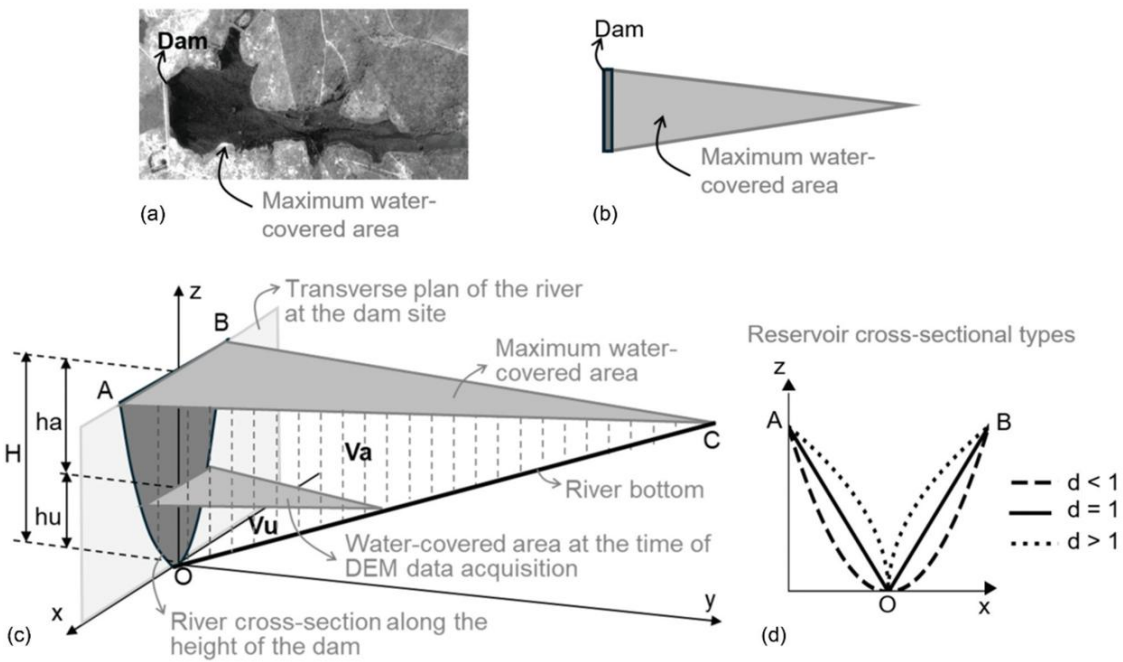
Phase 2: Area/Volume curves

- 3D reconstruction of surveyed reservoirs (>70 bathymetric surveys in 2015-17)
- Area/Volume curves
  - Normalization
  - Fitting mathematical curves
  - Statistical analysis of morphology parameters and A/V curves



Underlying logic

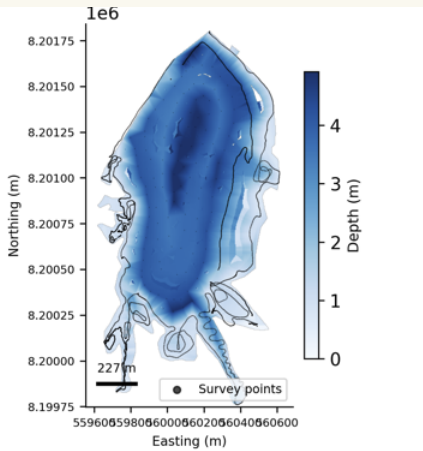
The reservoir bed and the surrounding topography are morphologically continuous, thus the topographic parameters of the riparian area are related to the underwater topography.

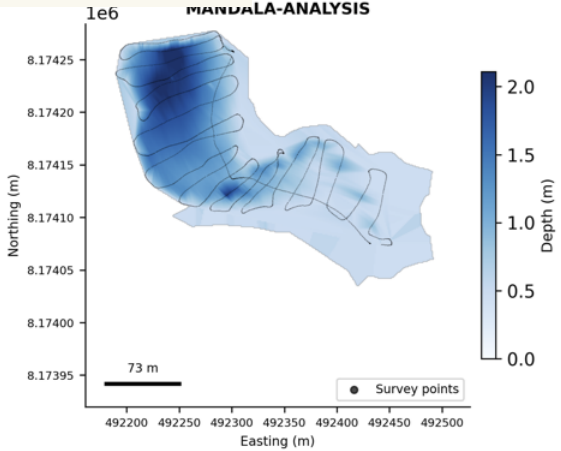


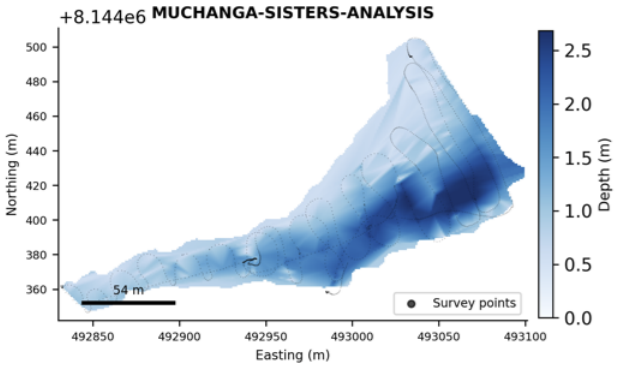
Source of figure: Lima et al. (2025), method from Liu et al. (2020),

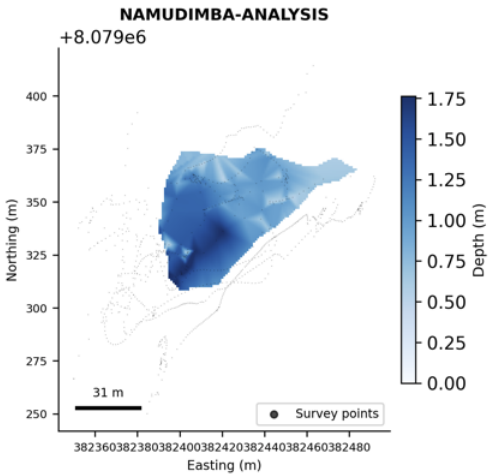
Phase 2: 3D Reconstruction

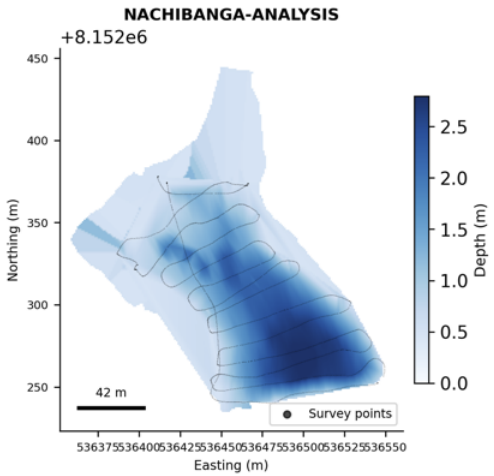
Selected Reservoir Sample
ion, adaptive resolution)

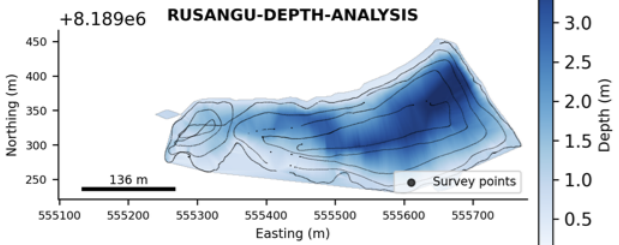




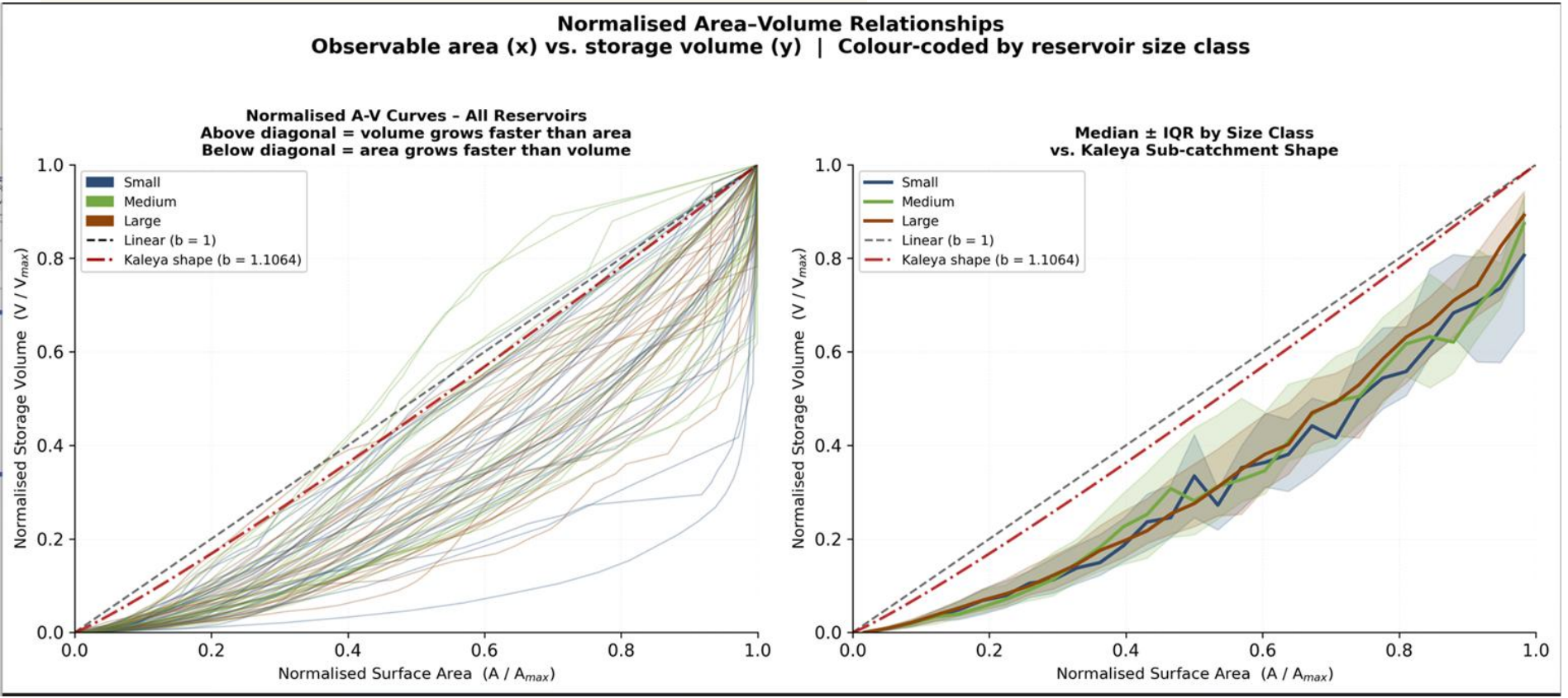




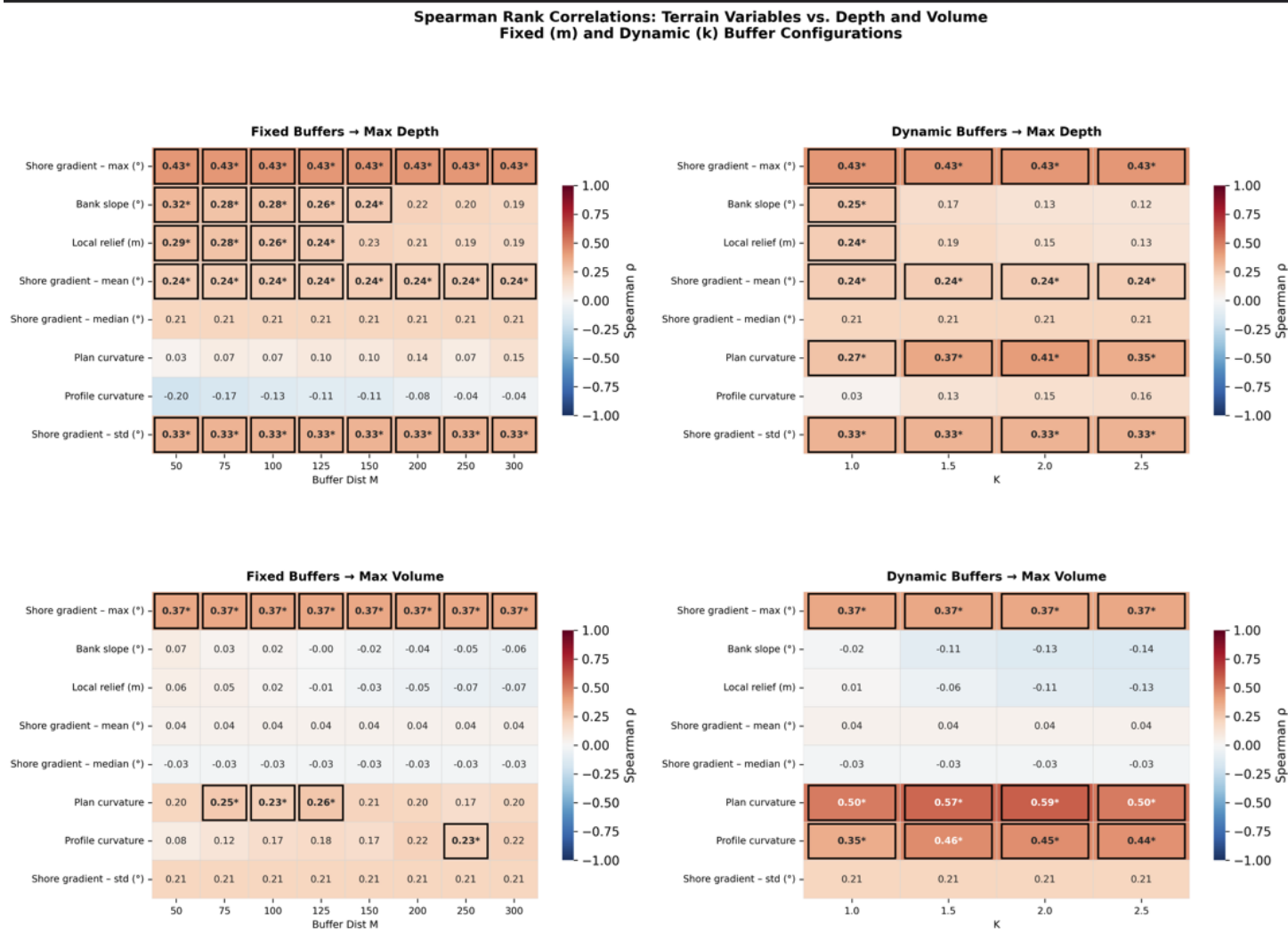




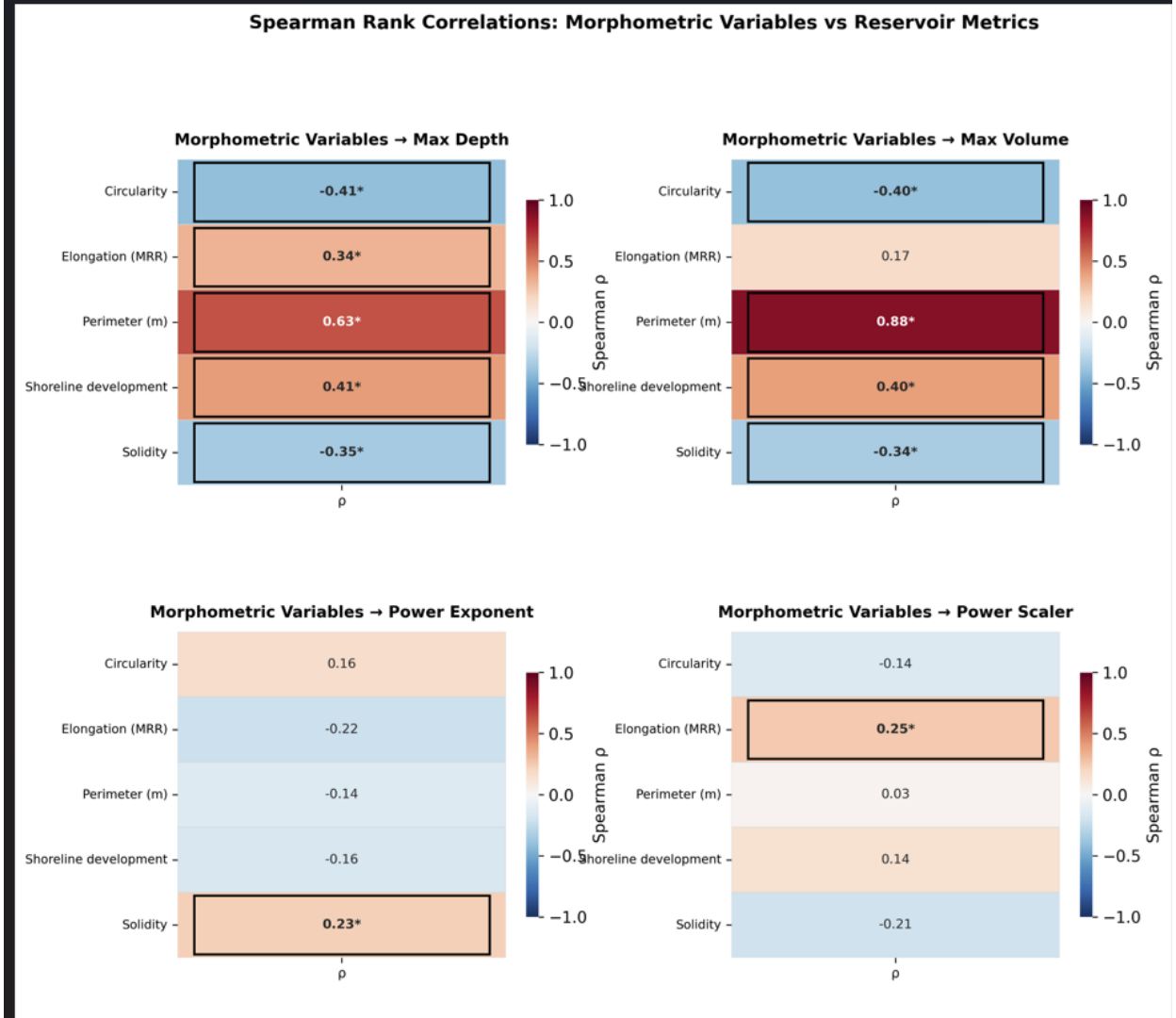
Phase 2: Normalised AV Curves



Phase 2: Spearman's - Volume & Depth Vs terrain



Phase 2 challenge: Correlation between Volume & Depth Vs Morphometric Features

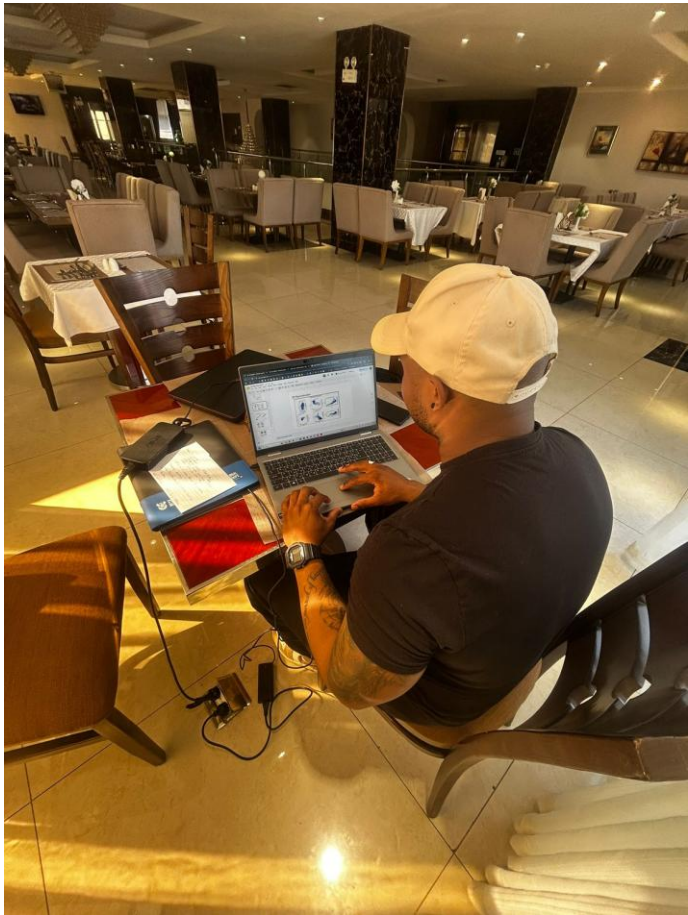


Fieldwork: validation data collection

Coming soon…

- Completion of statistical analysis (Phase 2) - September
- Validation of the method (Phase 3) - September
- Regional surface water calculation (Phase 3) - October
- Dashboard prototype, visualization (Phase 4) - December
- Publications - December and beyond
- Dissemination actions with stakeholders - November-December

The deadline is always coming too soon :-)



References

Lima, D. M., Paz, A. R., Rodrigues Martins, E. S. P., & Olivera, F. (2025). Improving small reservoir storage capacity estimation using DEM: inferring underwater volume at DEM data acquisition time. Hydrological Sciences Journal, 70(10), 1724–1743. https://doi.org/10.1080/02626667.2025.2498659

Liu, K., Song, C., Wang, J., Ke, L., Zhu, Y., Zhu, J., Ma, R., & Luo, Z. (2020). Remote Sensing-Based Modeling of the Bathymetry and Water Storage for Channel-Type Reservoirs Worldwide. Water Resources Research, 56(11), 1–19. https://doi.org/10.1029/2020WR027147

Thank you!