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Abstract

GEOSPATIAL AND HYDROLOGICAL ASSESSMENT OF SOBRADINHO RESERVOIR

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This study investigates the hydrological and water-quality dynamics of the Sobradinho Reservoir, located in the semi-arid São Francisco River Basin of Northeast Brazil, between 2000 and 2025. The reservoir is a key component of Brazil's water and energy system but faces growing pressure from recurrent droughts and increasing water demand. The extreme drought of 2013–2017 caused one of the most critical hydrological crises in recent decades, severely reducing reservoir storage, hydropower capacity, and water availability for agriculture and local communities. Understanding these drought impacts and the reservoir's recovery is therefore essential for sustainable water management and climate adaptation in the region.

To achieve this, the research combined remote sensing, climatic indices, and geospatial analysis using Google Earth Engine (GEE), Python, and QGIS. Precipitation data from CHIRPS, evapotranspiration from MODIS (MOD16A2GF), and turbidity from Landsat 8 (NDTI) were integrated with elevation–area–capacity analysis based on the COP30 DEM. The Standardized Precipitation Index (SPI) and Standardized Precipitation–Evapotranspiration Index (SPEI) were calculated to characterize drought frequency and intensity, while reservoir water loss was estimated from PET–precipitation balances and translated into volumetric terms.

The results reveal strong interannual rainfall variability and confirm the 2013–2017 event as an extreme multi-year drought, with SPEI values below -1.5 and a collapse of normal wet-season

rainfall. Evapotranspiration patterns show that PET consistently exceeded ET, reflecting sustained moisture stress typical of semi-arid systems. Annual net evaporation reached 1,300–1,740 mm yr⁻¹, equivalent to 5,400–7,300 million m³ of water loss. The elevation–capacity curve, derived from QGIS analysis, demonstrated how reservoir storage increases sharply between 386 m and 388 m and stabilizes near the spillway elevation (393.5 m), defining the hydrological limits of the basin. Turbidity maps showed greater suspended sediment concentrations during dry periods, indicating sediment resuspension under low-water conditions and clearer water in wet seasons.

Overall, the study demonstrates that drought propagation in the Sobradinho Reservoir follows a sequential process: rainfall deficits reduce inflows, evapotranspiration declines, surface evaporation intensifies, and water quality deteriorates. The integrated use of multi-source satellite datasets proved highly effective for diagnosing these relationships. The findings highlight the reservoir's vulnerability to climatic variability and reinforce the importance of remote-sensing–based monitoring for managing water storage, hydropower generation, and ecological sustainability in Brazil's semi-arid regions.