C110

2D simulations for sediment management options during Wadi flash floods in Sidi Salem Dam

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I. Introduction:

Tunisia's climate, marked by arid periods and intense floods, leads to increased erosion and sediment yield in rivers, impacting reservoirs. Sidi Salem Dam (SSD) depicted in figure 1, crucial for water security, has lost 30% of its initial capacity due to sedimentation. The challenge is intensified by the reservoir's unique morphology and the current emphasis on water retention over sediment control during droughts. This study aims to address the rising sedimentation issue by formulating effective management strategies, accounting for the dam's distinctive features, diverse rainfall patterns, and complex dynamics of upstream reservoir management.

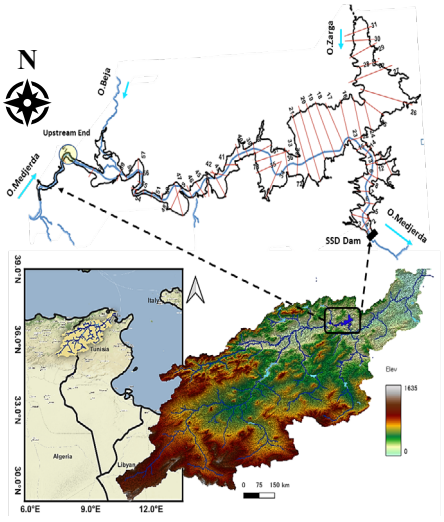

Figure 1: Study Area Location

II. Objectives and methodology

The study focuses on assessing and proposing tailored control measures for sediment management in the reservoir. Data limitations lead to estimations for sediment-related data, necessitated by the absence of historical data. Calibration relies on the 2017 bathymetric survey. The methodology includes an extensive simulation covering all flood events between 2006 and 2017, utilizing Telemac2d for morphodynamical analysis. The sediment boundary condition determination employs Ghimire et al's approach, relying on bed shear stress calculation due to data unavailability. The calibrated model exhibits good agreement with the 2017 bathymetric survey.

III. Sediment dynamics assessment

After calibrating SSD numerical model, the sedimentation dynamics analysis unveiled distinct flow patterns influenced by the reservoir's morphology, with a significant portion of sediment depositing far upstream before reaching the reservoir wall. This underscores the inefficiency of current reservoir operations. Cumulative bed evolution indicates preferential deposition zones that vary across reservoir regions from upstream to downstream. Region-specific analysis depicted in figure2, identifies unique deposition characteristics, including embayment deposition in Region 1, bank-oriented deposition in Region 2, axial deposition in Region 3, and deltaic behavior at the boundary between Regions 3, 4, and 5.

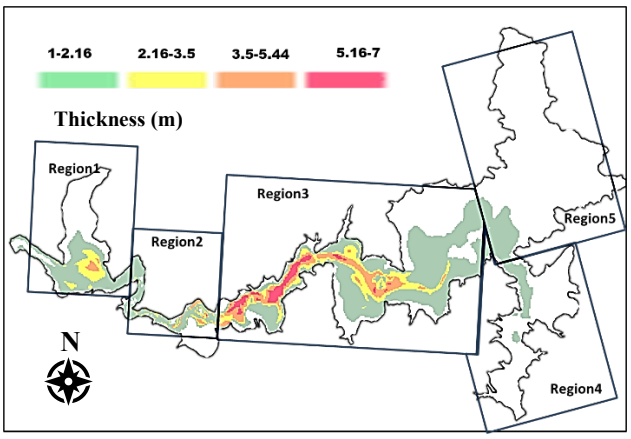

Figure 2: Simulated Cumulative Sediment Thickness in m

These results emphasize the need for tailored management strategies, suggesting that a uniform approach may not be optimal for effective sedimentation control across the entire reservoir.

IV. Sediment control options:

The sediment management assessment for the Sidi Salem reservoir utilized both long-term and event-based analyses. The long-term projection depicted in figure3 indicates a substantial loss of nearly 50% of the initial capacity by 2040, prompting the exploration of alternative strategies.

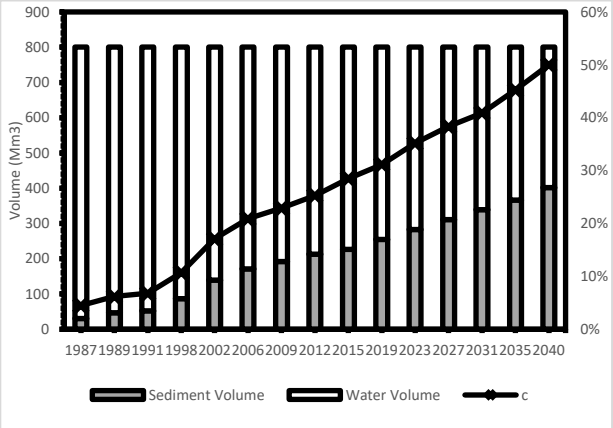

Figure 3: Simulated predicted Storage Evolution

In event-based testing with flash flood scenarios, five sediment management options were evaluated depicted in figure 4, revealing that Option 5, featuring a bypass tunnel with a diversion weir and a dredging channel, demonstrated optimal performance allowing to recover 30% of the silted storage. The efficiency of each option was assessed based on the reservoir's specific characteristics and silted capacity.

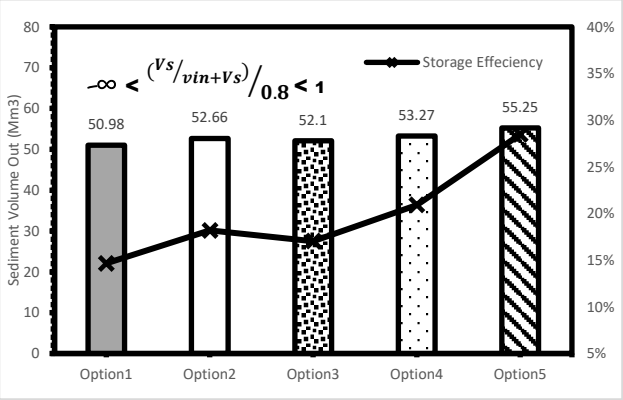

Figure 4: simulated flushed sediment volume per option.

Cumulative sediment volume results in figure 5 indicated varied deposition and erosion patterns across regions and options.

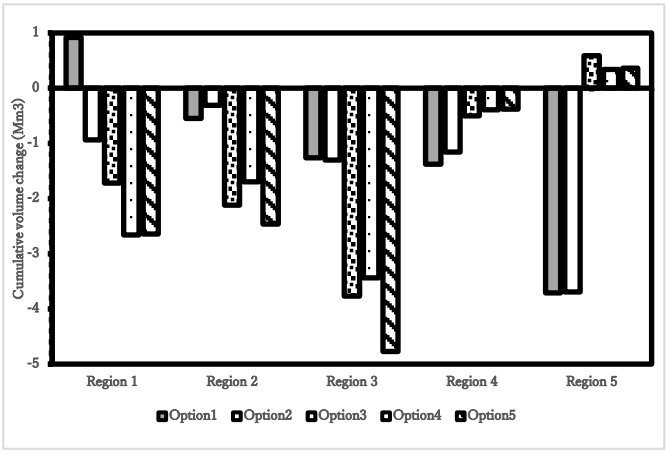

Figure 5: Cumulated Volume change per reservoir region

Option 5 showcased superior performance in evacuating sediment from the most affected regions, specifically Region 1 and Region 3. In contrast, Option 2, involving sediment flushing combined with channel dredging, exhibited a more uniform pattern with notable erosion in region 4 and 5, particularly influenced by the currents from the bottom outlet structure.

V. Conclusion:

The study's findings reveal that sedimentation patterns in the reservoir are strongly influenced by both morphology and current operational strategies. Conventional sediment control measures, unsuitable for arid conditions due to potential water loss, are not recommended. The optimal approach advocates for a tailored combination of management options, emphasizing region-specific strategies within the reservoir. Specifically for Sidi Salem Dam, the installation of a bypass, coupled with dry dredging during the drought season in the upstream region, emerged as the most effective solution for storage recovery.