



Studying Sedimentation of the Ghrib Dam Using Model Builder ArcGIS Application

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Abstract

The Cheliff-Ghrib watershed is characterized by strong relief and significant erosion, which accelerates the siltation phenomenon in the region. In 2004, the siltation rate was estimated at around 58.81%. A settling dam (Boughezoul) was built upstream of our dam to mitigate this phenomenon. The dike was also raised. Over the past 15 years, our dam has constantly been exposed to the siltation problem, which threatens its storage capacity. In this context, our study evaluates the Ghrib dam siltation by integrating geographic information systems (GIS). The bed evolution of the Ghrib dam was mapped, considering the results of two bathymetric surveys (2004–2019). Using the Model Builder ArcGis application allowed us to draw the erosion-deposit map. This last constitutes an excellent cartographic tool to aid in decision-making for dam managers, allowing the identification of erosion and sedimentation zones at the bottom of the Ghrib dam reservoir. It also makes it possible to estimate the volume of sediment deposited or eroded on the reservoir bed. 15.62 Mm³ of silt has been deposited over the past 15 years. However, the volume of eroded sediment was estimated to be around 23.49 Mm³, particularly at the level upstream river.

Keywords

Dam · Cheliff-Ghrib · Siltation · GIS · Model builder

1 Introduction

In the realm of water resource management, settling dams play a pivotal role in mitigating siltation, a persistent problem threatening the efficiency of reservoirs. The accumulation of sediment over time significantly impacts storage capacities and water quality. Addressing this challenge necessitates innovative approaches. Modeling bathymetric data emerges as a crucial solution, enabling the comprehensive assessment of sedimentation phenomena. By utilizing Geographic Information Systems (GIS) and conducting bathymetric surveys, experts can meticulously map the reservoir bed's erosion and deposition patterns. This modeling not only facilitates the estimation of sediment volumes deposited or eroded but also offers valuable insights for strategic decision-making. Through these advancements, the study and management of settling dams enter a new era of precision and efficiency, ensuring sustainable water resource utilization. The sub-basin of Cheliff-Ghrib is part of the upper and middle Cheliff watershed (Fig. 1). The latter belongs to the large Cheliff basin, which represents the primary water resources in the western Algerian region (Harkat et al., 2011).

Our study area is characterized by strong erosion, which accelerates the siltation phenomenon in the region. The Ghrib dam is located on the Cheliff river, 20 km southwest of Ain-Defla. This dam is intended for irrigation, water supply, and transfer to the Bouroumi dam for an annual regulated volume of 105 million m³ (Agence nationale des barrages et transferts/1er Trimestre, 2018). In 2004, the siltation rate of the Ghrib dam was evaluated at about 58.81% (Rapport Technique, 2004). The accumulated sediments in the reservoir have significantly reduced their storage capacity; consequently, their life span has been limited. In 2019, the c Ghrih dam's capacity was estimated at 169.35 Hm³ per the national agency of dams and transfer of Algiers (Rapport Technique et al., 2019). In addition, the siltation rate of the reservoir was estimated to be 39.51%, according

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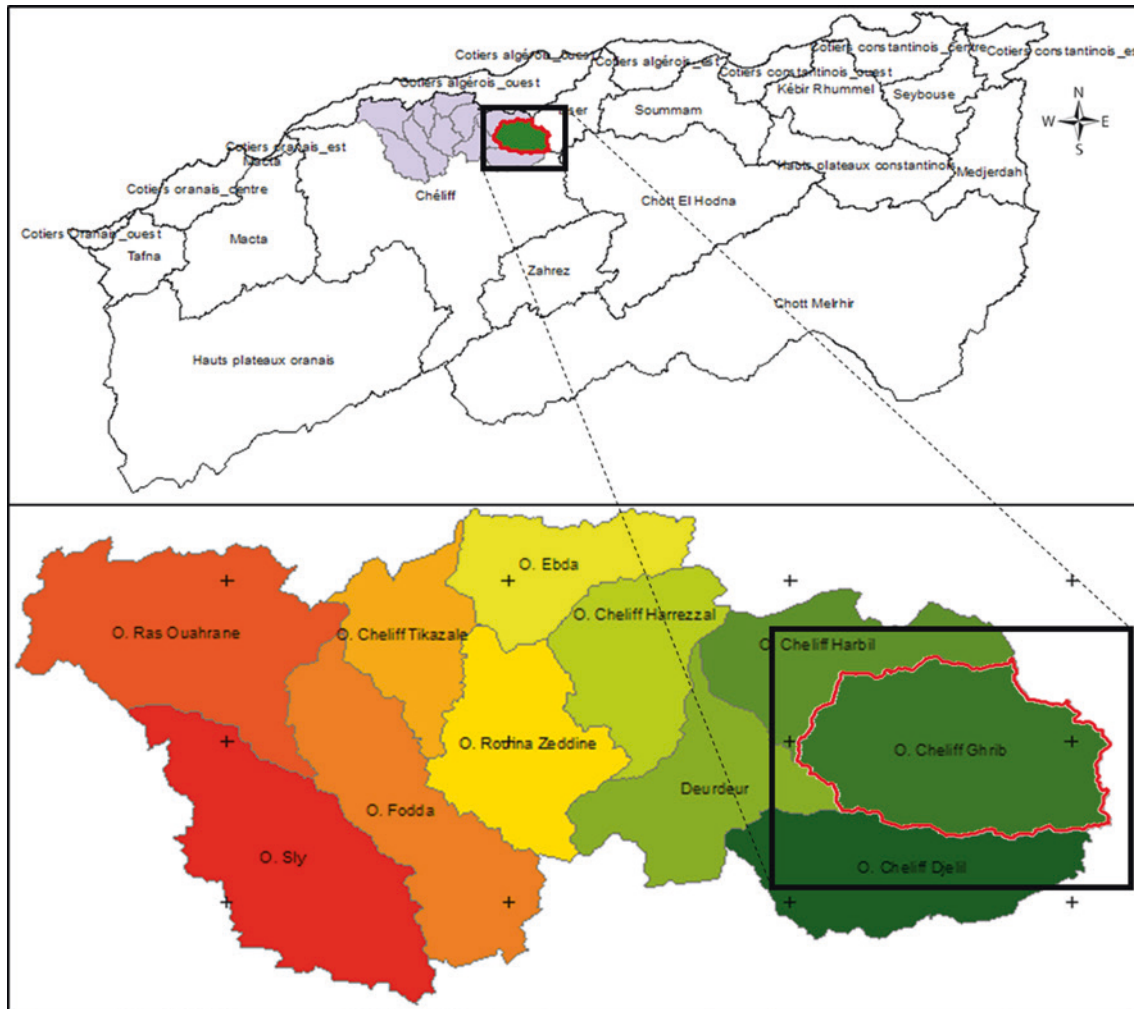


Fig. 1 Geographic location of the Cheliff-Ghrib sub-basin in Algeria

to the latest surveys (Ghecham, 2021). Predicting the volume of sediment deposited in the reservoir is very important for the good management of the dam, especially for predicting the dredging or de-silting operations of the reservoir. Integrating geographic information systems allows for minimizing the effort (Knijff et al., 2000) and creating a good database through the geographic analysis of the elaborated maps. This is the context of our study, which aims to predict the silting of the dam Ghrib by the Model Builder application on ArcGis™.

2 Methods

Model Builder is a visual programming language to create, modify, and manage models within ArcGIS (Chaaban et al., 2019). This model is geoprocessing, represented as a diagram that looks like a flowchart. It stores all the information necessary to run the processes and create the output data in ArcGIS (ESRI, 2000).

To indicate the status of tools and variables, the model builder uses several colors (Software: ArcGIS 10.2.2, 2014). Inputs as blue ovals (e.g., dam limit, interpolated bottom for both years 2004–2019), outputs as green ovals (values generated when the model runs), tools as orange rectangles (operations to be performed on the input data), connecting arrows that indicate the processing sequence, and text labels that explain the model (Schaller & Mattos, 2010). Our model is illustrated in Fig. 2.

3 Results

3.1 Elaboration of the Erosion–Deposition Map

Following the execution of the above model, the erosion–deposition map was obtained. This map identified the sedimentation and erosion zones on the bed of the Ghrib dam (Fig. 3).

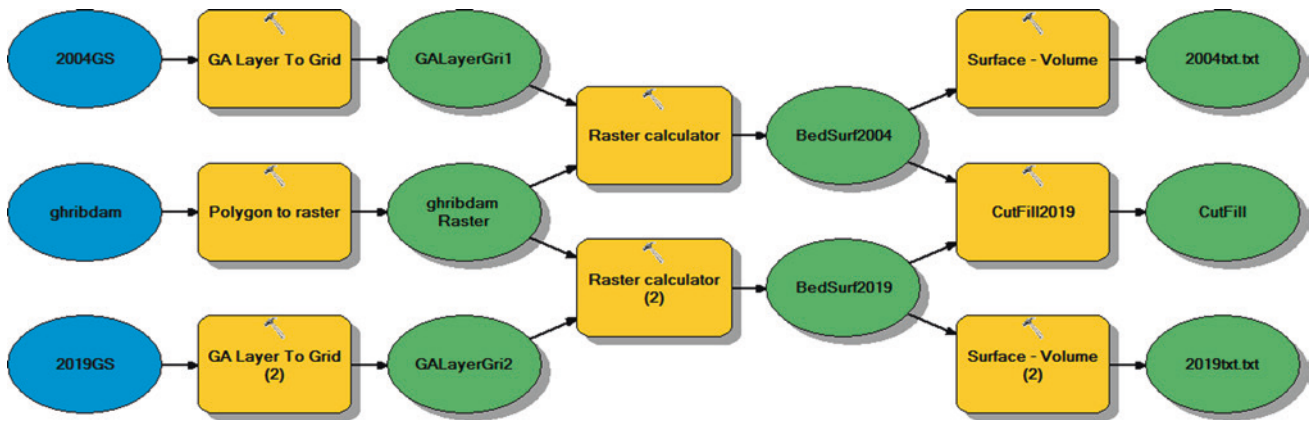
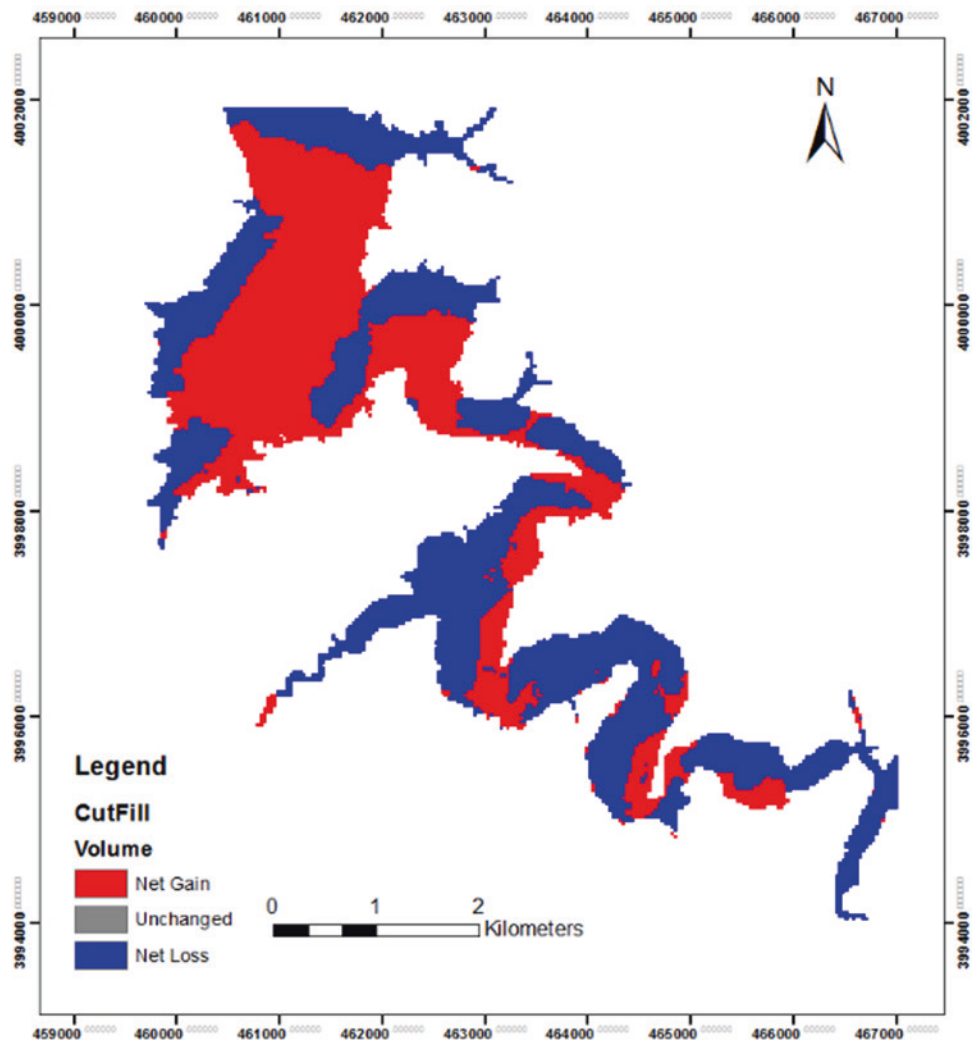


Fig. 2 Diagram of the erosion and deposition map model (Model Builder interface)

Fig. 3 Erosion–deposition map of the Ghib dam reservoir



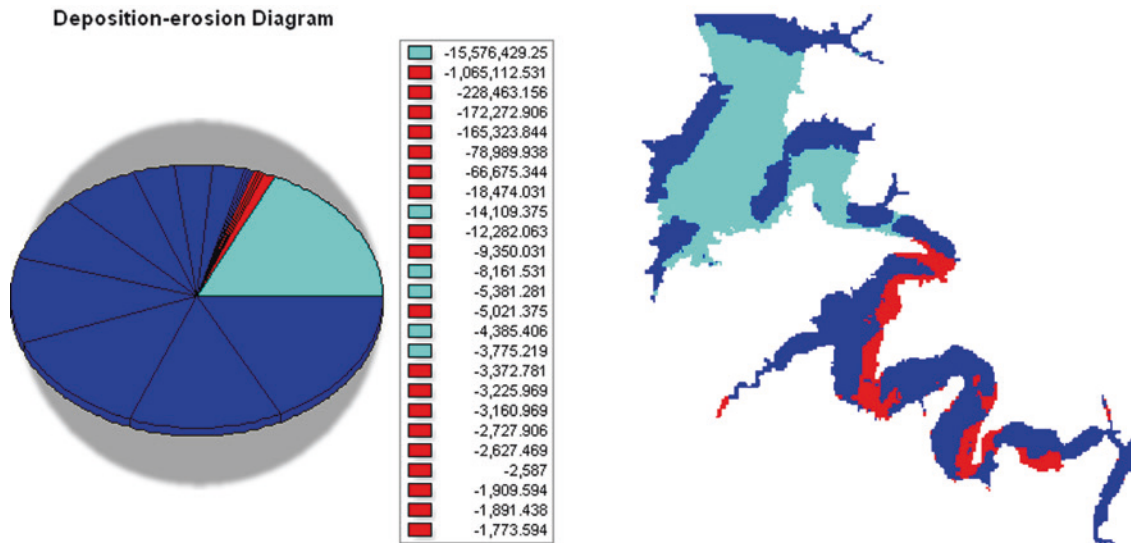


Fig. 4 Diagram CutFill

4 Discussion

On the above map, it appears that the deposition areas cover most of the dam bed. The erosion zones on the banks and the left and right ends of the map indicate the proper operation of the bottom gates during sediment discharge. However, the accumulation of deposits in the center of the reservoir indicates the presence of density currents that enter the reservoir during flood periods. The diagram in Fig. 4 also illustrates the enormous quantities of sediment deposited at the bottom of the Ghrif Dam reservoir.

The total volume of sediment deposited at the bottom of Ghrif Reservoir during 2004–2019 can be calculated in excel or using the statistical tool based on the attribute table of deposition areas and volumes in ArcGis. This volume was estimated at 15.62 Mm³. However, the volume eroded by the river upstream is estimated at 23.49 Mm³. This indicates the huge amount of deposition at the dam and the large solid transport upstream of the river (Ghecham, 2021).

5 Conclusion

In this study, we have developed a map that allows the identification of erosion and deposition areas at the level of the Ghrif Dam reservoir based on the data of the last two bathymetric surveys done, respectively, in 2004 and 2019. This map is considered a basic tool for the dam managers,

since it allows to intervene at the appropriate place, especially for the operations of flushing and siltation. It also allows the quantification of the volumes deposited or eroded at the level of the Ghrif dam.

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