Research Article

Annals of Marine Science Research

Predictive Study of Silting and Durability of Tessa Planned Dam -Tunisia

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Submitted: 14 August 2024 **Accepted:** 20 August 2024 **Published:** 28 August 2024

Citation: *Hajji, O., Abidi, S., El Azem, A., & Jarray, B. (2024). Predictive Study of Silting and Durability of Tessa Planned Dam -Tunisia. A of Mar Sci Res, 1(1), 01-04.*

Abstract

The mobilization and exploitation of surface water are ancient practices in Tunisia. Solid inputs from upstream watershed threats the life of Dams that cause its siltation. Predicting the rate of erosion upstream the dam is very important in order to monitor and manage the siltation problem and to designate adequate means to reduce its extent. The main objective of this paper is to estimate the siltation rate of Tessa planned dam by RUSLE model (Revised Universal Soil Loss Equa-tion). To apply the model, the use of mapped field information requires the use of a Geographic Information System to properly plan the man-agement actions to be taken and to protect priority areas at erosion risk.

The simulation of the thematic maps of the RUSLE factors, will allow a very efficient way to unravel the complexity and the interdependence of the factors, such as slope, soil erodibility, rain erosivity, land cover, and existing landscaping; to predict the volume of the vase the current rate of sediment according to the model is therefore (53 t/ha/year); the sediment rate in the dam is expected to be in the order of 950 Mm3. After integration and combination of scenarios, this rate will decrease by 10%.

Keywords: Soil Loss, Dam Siltation, RUSLE, ArcGIS.

Introduction

In Tunisia, the phenomenon of dams silting reaches very high values, it is the dramatic consequence of the watershed erosion. More than 95% of the silt arrives on the reservoirs. On this point Tunisia with its arid and semi-arid climate, its rainfall with torrential character, its low vege-tation covers its low vegetation cover is subject to the phenomenon of erosion whose dams receive annually a quantity of receive annually a quantity of silt estimated at 30 million m3/year [1].

So, to reduce the consequence of this phenomenon, and model dams' sustainability, the mapping of soil loss becomes an indispensable need because they allow to realize an accurate evaluation of soil transport on the watershed.

In fact, this study aims to predict the volume of silt that will be depos-ited in the proposed dam of Tessa by the empirical model RUSLE in-corporated in a geographic information system. To determine the areas of high risk, a cartographic study was integrated based on field surveys, remote sensing data and topographic data.

Study Area

Tessa watershed is a sub-catchment of the Medjerda, located in the North-West of Tunisia, in the southern region of Haut-Tell and which has significant inputs (average of 100 Million m3). It has contributed to several showers to flood the city of Bousalem located downstream rep-resented in the figure.

Its catchment area of 2605 km² is formed by a succession of plains con-nected to each other by valleys very steep.

The climate of the study area is Mediterranean throughout the year, and the rainfall is irregular; the average annual rainfall of the basin varies from 85 mm to 771 mm.

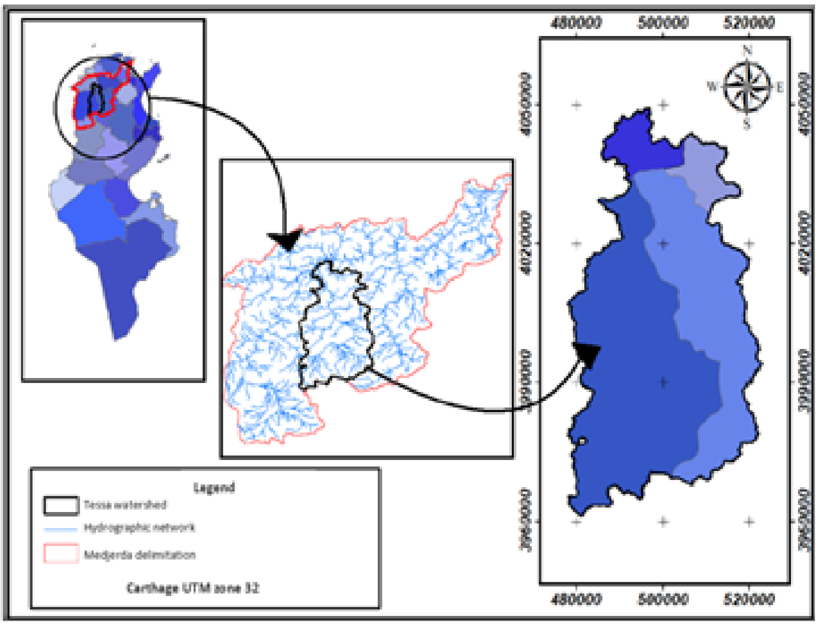


Figure 1: Watershed localization

Methodology

RUSLE model allows you to predict the average annual rate of soil erosion for scenarios involving systems of culture, management techniques and practices to control erosion [2]. RUSLE calculates the average annual erosion expected "A" on the slopes by multiplying several factors:

$$A=R*K*LS*C*P \quad (1)$$

Erosivity index (R), Soil erodibility (K), Length of the slope and Slope (LS), Land cover (C), and Conservation practices (P).

These factors are generated from different maps: Slope, Cover soil, Pedology, Water and Soil conservation techniques. It also requires the digital elevation model (DEM) and represents an extension of the incorporation of RUSLE in a framework of GIS [2]. Concerning erosivity index (R), was calculated using the formula of Arnoldus [3].

$$R = 1.3735 \times 10 \times (1.5 \times log \sum \frac{P_i}{P}) - 0.8188 \quad (2)$$

Where Pi and P the monthly and annual rainfall data collected from 17 rainfall stations.

LS factor is calculated using the formula below, where S is the slope map:

$$LS = (flowaccumulation * \frac{resolution}{22.1})^{m} \times (0.065 + 0.0045 * S + 0.0065 * S^{2}) \quad (3)$$

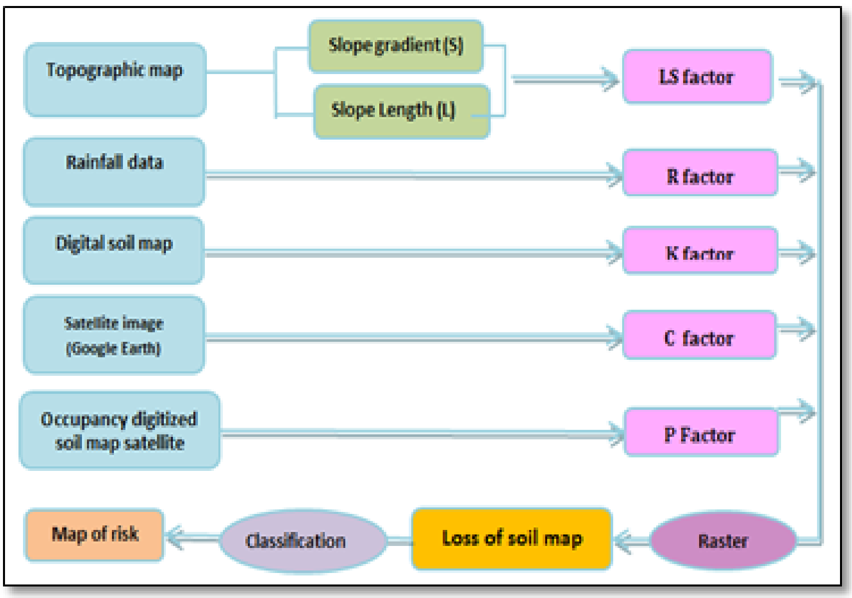


Figure 2: Methodological Flowchart

The calculation of soil loss will be done using parameter generated from the area upstream the Dam.

Results

RUSLE Factors

K, C and P factors are derived from soil map, cover soil and water and soil conservation techniques based on experimental results of Mas-son, Heusch in Mediterranean area as well as of various compilations [4, 7].

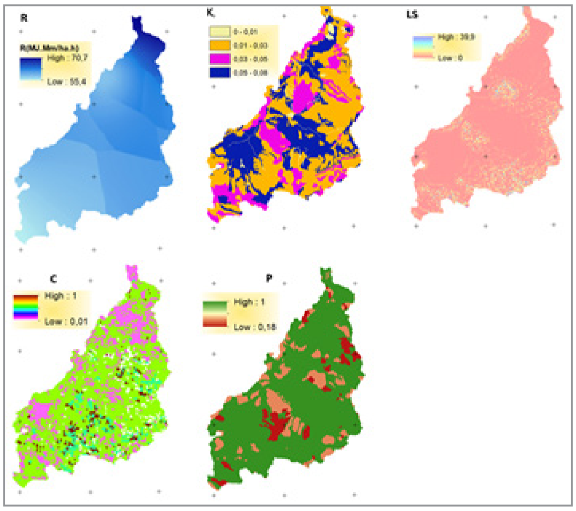


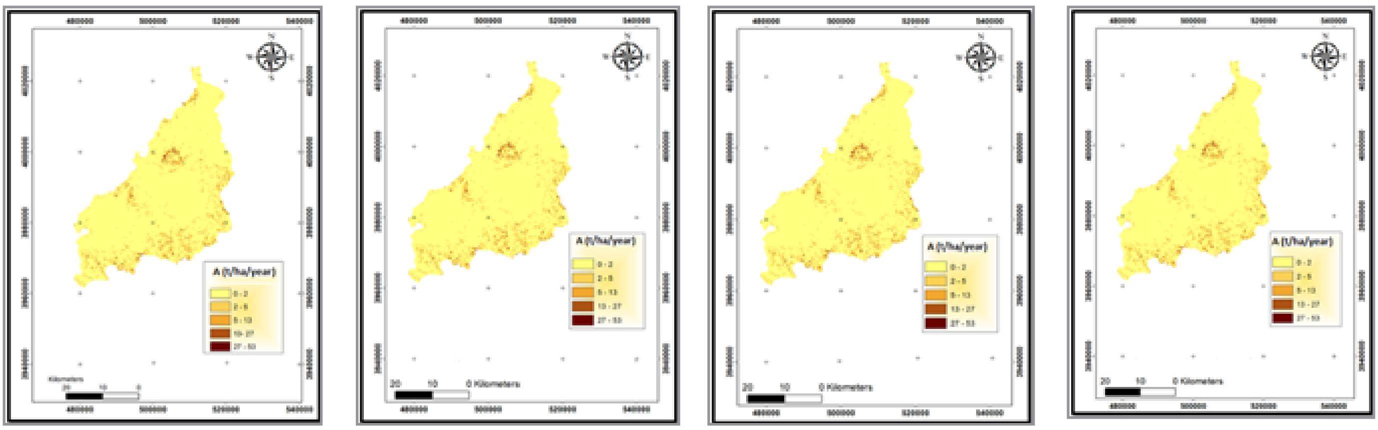
Figure 3: RUSLE factors

Soil Loss

The results of RUSLE application derived the soil loss map (fig-ure 4). To reduce the erosion effect, we suggest suitable water and soil conser-vation techniques. Then we calculate the soil loss considering each technique: Extension of the pasture, Re-forestation, and Installation of mechanical benches (figure 4).

Table 1: % Area covered by each class of soil loss

Class (t/ha/year)	Actual	Extension of pasture	Reforestation	Mechanical benches	Scenario combination
0 - 2	91.00	91.34	91.39	90.92	91.61
2 - 5	5.21	5.20	5.17	5.52	5.31
5 - 13	2.71	2.70	2.65	2.79	2.49
13 - 27	0.63	0.63	0.65	0.64	0.49
27 - 53	0.11	0.10	0.12	0.10	0.075
Total soil loss (t/ha/year)	29.30	22.33	22.52	22.34	19



(a) (b) (c) (d)

Figure 4: Soil loss maps: (a) actual situation, (b) extension of pasture, (c) with reforestation, (d) with mechanical benches

Discussion

In general, erosion affects the entire watershed, although almost 90% of the watershed is characterized by low erosion risk rates, and the rest of watershed is subject to high erosion.

Based on RUSLE modeling, the conservation techniques reduce the soil loss by an average of 23%. The soil loss is reduced more: on the 1st class by Mechanical benches, on the 2nd and 3rd classes, by Reforesta-tion and for the 4th and 5th classes by Extension of pasture. The combi-nation of the three scenarios, reduced considerably the soil loss for each class and the total rate to 19% [8].

Conclusions

RUSLE model applied using ArcGis, is provides synthetic and system-atic information on the intensity, spatial distribution of the phenomenon that will be used to identify priority areas of intervention in order to solve many problems of crop, soil and management of watersheds. The 1st scenario, the Extension of pasture, decrease the average erosion val-ue of 6.96 t/ha/year. On the 2nd scenario, the reforestation, the average erosion becomes 22.34 t/ha/year. The 3rd scenario, reinforcement of me-chanical benches, reduced the average value of erosion from 29.30 t/ha/year to 22.34 t/ha/year. The 4th scenario, the combination of the three scenarios reduced the average value of erosion from 29.30 t/ha/year to 19 t/ha/year.

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