UNIVERSITÀ DEGLI STUDI FIRENZE

Evaluation of mining decommissioning strategies on catchment hydrology

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EGU General Assembly 2020

General Objective:

Strategies definition to reduce the negative effects of **abandoned mining sites** on catchments **where an artificial reservoir is present.**

Methodology:

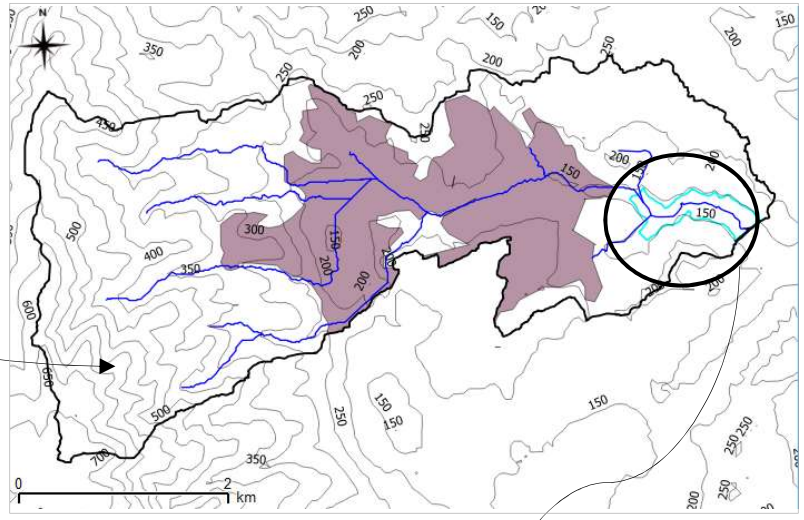
Sediment management at the catchment scale to promote **sustainable water resources development** through **environmental restoration** of the mining area.

How?

Analyzing different scenarios on SWAT (**Soil Water Assessment Tool)** through modifications of **MUSLE equation**, i.e. changing parameters of **land use** (C_{USLE}) or of **river basin morphology** (LS_{USLE}).

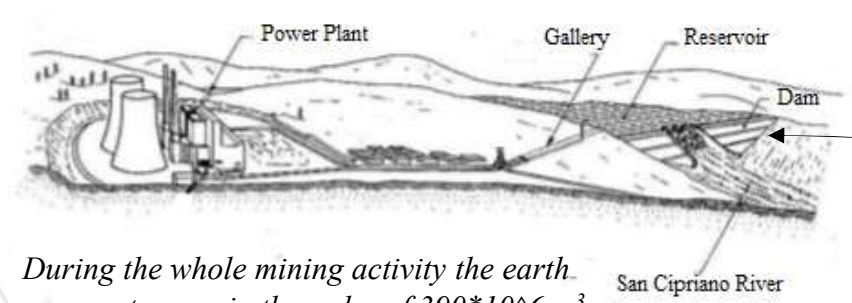
$$sed = 11.8 \cdot \left(Q_{surf} \cdot q_{peak} \cdot area_{hru}\right)^{0.56} \cdot K_{USLE} \cdot C_{USLE} \cdot P_{USLE} \cdot LS_{USLE} \cdot CFRG$$

Overview of the Study Area

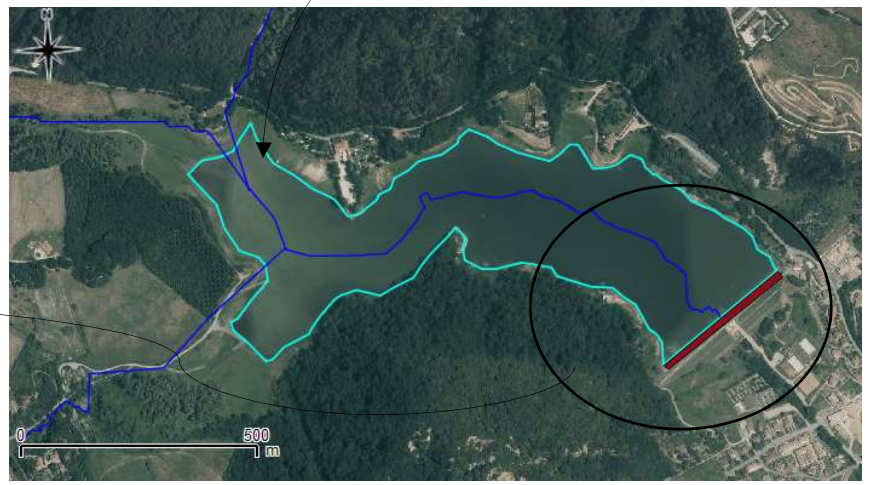


Castelnuovo dei Sabbioni was one of the most important lignite mines in central Italy

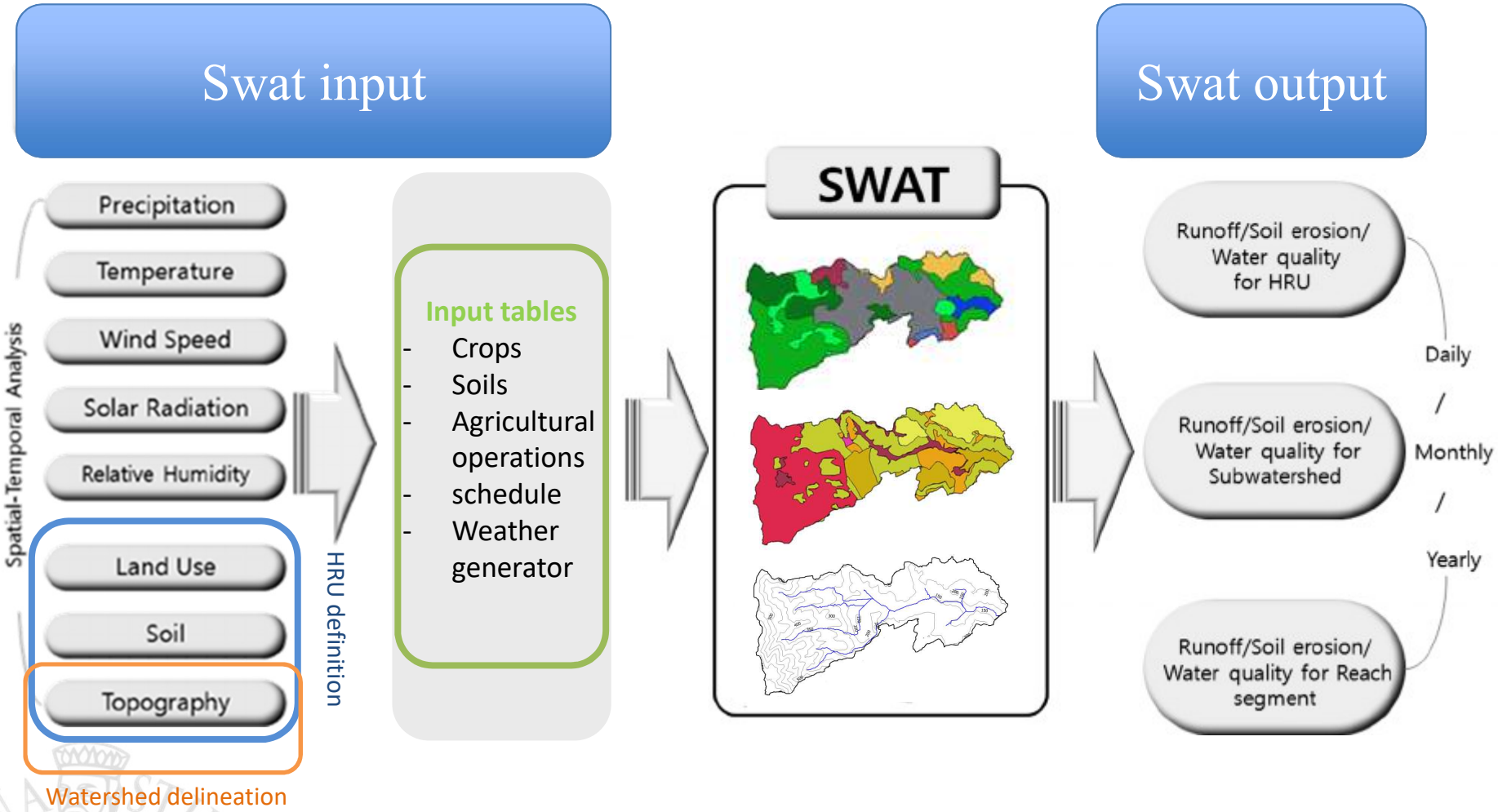
LEGEND
- Contour lines (m asl)
- San Cipriano River
- River Basin
- Dam
- Lake San Cipriano
- Former Mining Area



*During the whole mining activity the earth movements were in the order of 390*10^6 m^3*



Soil Water Assessment Tool



Baseline and decommissioning scenarios

Baseline Scenario
Current scenario used for the model calibration

Renaturation Scenario
Conversion of the mining site with deciduous and oak forests
change of C_{USLE}

Landscape restoration
Changing the structure of the river network, i.e. catchment area
change of C_{USLE}, LS_{USLE}

Percentage of area with a specific landuse

	BASELINE	SCENARIO 1	SCENARIO 2
URMD	2.1	2.1	1.3
APPL	1	1.1	1.9
GRAP	2.5	2.5	2
OLIV	6.5	8.5	7.1
UIDU	0.7	0.7	0.8
WATER	2.8	2.8	4.9
ARGL	8.6	12.8	13
FRSD	16.1	22.3	10.7
OAK	33.7	47.2	58.3
MINE	26	0	0

Model Calibration on SWAT

Three bathymetries campaigns took place on the lake in the years 2002, 2011 and 2016, therefore **two different reservoir silting volumes are available**.

Period	silting volume [m^3]	Mean annual silting rate [m^3/yr]
2002-2011	208000	23000
2011-2016	62000	12000

Since San Cipriano is an **ungauged river basin** the model has been calibrated on the **sediment transport equation** (2) with an **iterative calibration** (1) using the mean silting volume of the 2011-2016 interval as the land use data refer to the year 2013.

$$RE\ (x) = \frac{|S_{obs}(x) - S_{mod}(\theta, x)|}{S_{obs}(x)} .100 \qquad (1)$$

$RE(x)$ = error at Lake San Cipriano location
θ = parameter of the calibration
S_{obs} = 12000 m^3/yr
S_{mod} = modelled silting rate

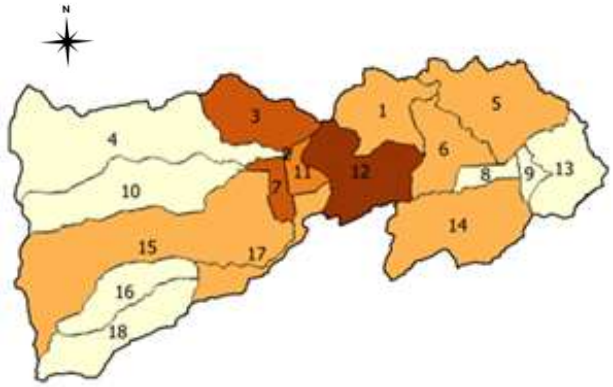
Calibration Objective = $RE < 3\%$

$$conc_{sed,ch,max} = conc_{SP} \cdot v_{ch,pk}^{SPEXP} \qquad (2)$$

θ	initial value	final value
$conc_{SP}$	0.0001	0.01
SPEXP	1	1.075

Scenarios results for sediment yield

1



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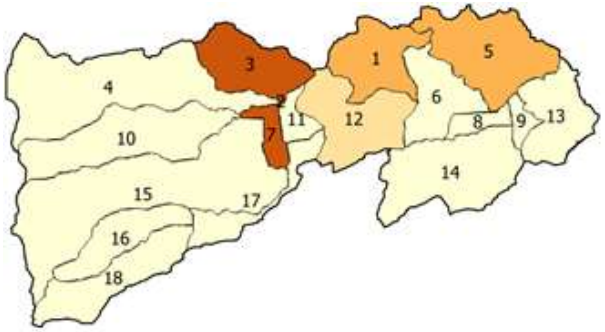

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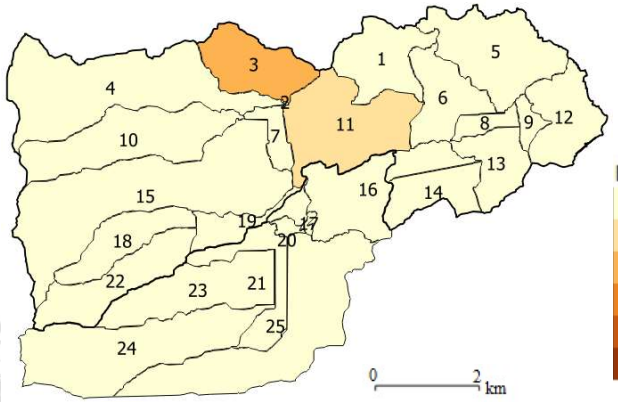


Mean annual silting rate (m3/yr*ha)
0.0 - 3.5
3.5 - 7.0
7.0 - 14.0
14.0 - 21.0
21.0 - 28.0
28.0 - 35.0

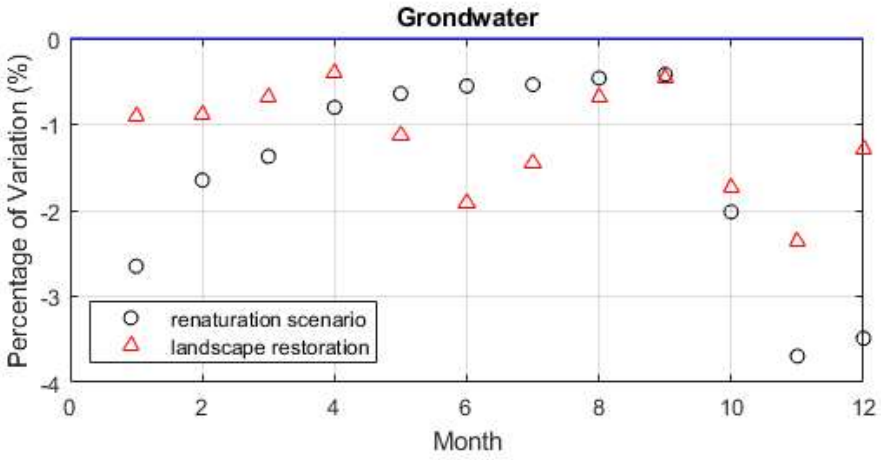
The 2011-2016 modelled mean silting rate of the three scenarios (S_{mod}) show different percentages of reduction Δ, if compared with the observed mean silting volume of the previous period (2002-2011), i.e. 23000 m³/yr.

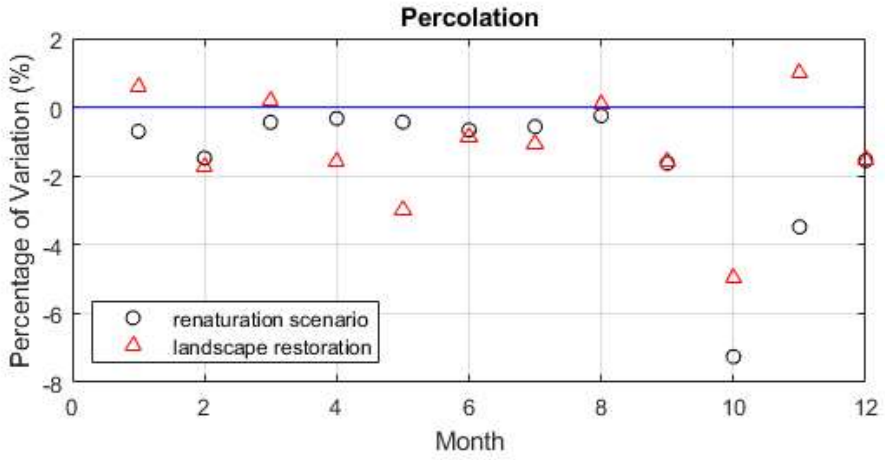
		S_{mod}(m³/yr)	Δ (%)
1	Baseline Scenario	11625	49.5
2	Renaturation Scenario	5441	76.3
3	Landscape restoration Scenario	2968	87.0

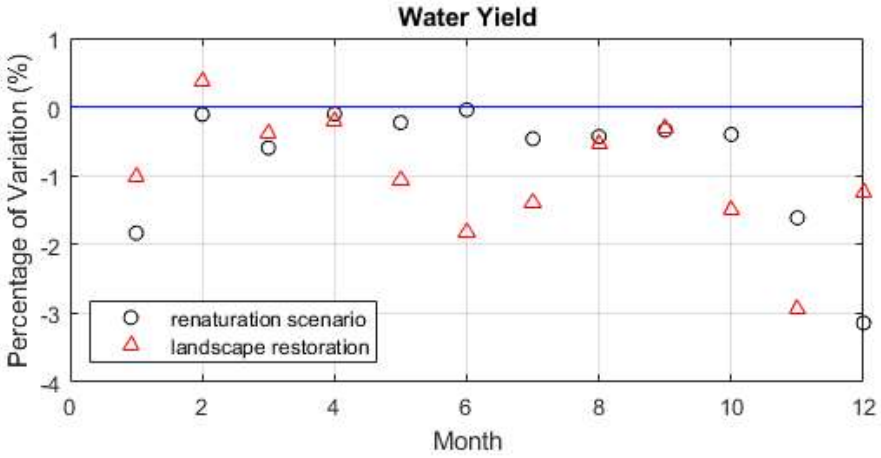
$$\Delta = \frac{S_{obs,2002-2011} - S_{mod}}{S_{obs,2002-201}} * 100$$

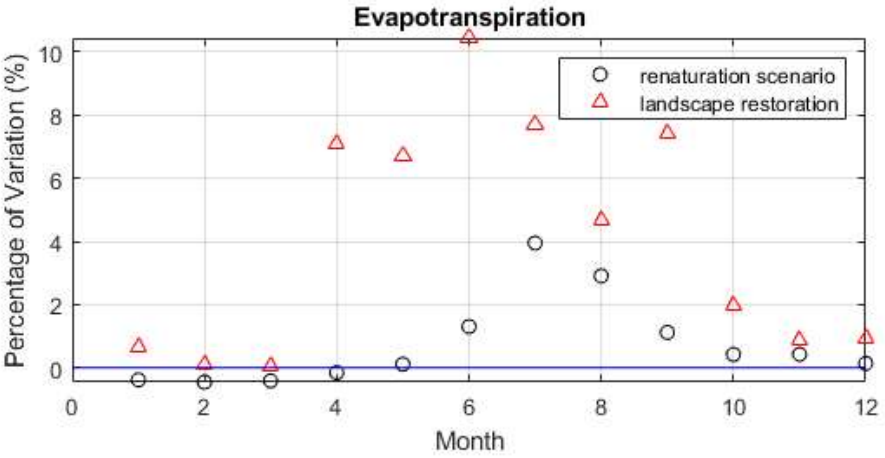
Scenarios results for other model outputs

Percentage of variation between the two decomissioning scenarios and the current situation









Concluding comments:

- Mining activity causes the increase in soil loss and the reservoir storage reduction
- Re-naturalize former mining sites leads to a strong reduction of sediment yield and to a conservation of the water resource
- A reduction of water yield and an increase of the evapotranspiration in the renaturalized mine area were detected
- Hydrosedimentological modelling is suitable for decision makers to choose mining decommissioning strategy

Under review on Journal of Hydrology:

Mining activity impacts on soil erodibility and reservoirs silting: evaluation of mining decommissioning strategies.

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